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A Process Based Model of Business Incubator in Systems Engineering Terms

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Abstract: Business incubators (BI), accelerators (BA) and science parks (SP) are widely recognized as ways of fostering innovation and help economy growth. This paper presents a functional model describing their operation (although with a focus on BI), identifying the points of need/provision of information as necessary to support decision-making for the management and monitoring of the system efficiency and effectiveness. The proposed model may also help planning the functioning and structure of BI / BA specific Information Management System (IMS) focused on data provision for strategy and decision support. The proposed approach is aligned with the intent to maximise process efficiency and effectiveness in supporting residents as well as granting them all the functionalities of a large corporate IMS while attending the program, additionally, it offers the possibility to generate extra income by providing alumni with IMS services at cost (thus creating a new model of BI / BA which operates also as a service provider).
Keywords: *Business Incubator/Accelerator, Science Park, Operation Model, Operation Process, Metrics, Key Performance Indicators, Efficiency, Effectiveness, System Monitoring & Management, Information Management Systems, PCDA cycle.*

Introduction

Our empirical findings are based on in-depth case studies of over a dozen Incubators / Accelerators, 25 semi-structured interviews with managers of Incubator / Accelerator in Europe, Belarus, Kazakhstan and Egypt, as well as EU incubator benchmarking surveys, guidelines for business incubator development, and reports on business incubators' best practices. Interviews with the heads of technology transfer offices of two top technology universities in Kazakhstan and one in Belarus have also informed the model along with the authors' direct involvement in the launch of one incubator in Kazakhstan and one in Italy as well as the interaction with **3iCampus** and **FasterCapital** Incubators in Israel and UAE respectively.

The starting point of this research has been the supervision of Passerini (2016) research on the London metropolitan area business incubators/accelerators performance analysis (un-published thesis, available by permission of the author). The lack of information about failures and the controversial opinion of some authors – as per (Tavoletti, 2013) – have sparked the desire to understand why so, and triggered the current research. Starting from the analysis of

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the most common BI definition and functioning approach reported in best practices and guidelines in UK (NESTA, 2014; BEIS, 2018; Clarysse et al, 2015; Dee et al, 2015; Miller & Stacey, 2014 ; Dee et al, 2011 ; Miller & Bound, 2010), EU (Anca, 2017; Avnimelech et al, 2007; Frenkel et al, 2008), and USA (InBIA, 2016) it was apparent that there was still no clear agreement on what BI are (see Appendix 1).

Table 1 – Sources of information and data used in the study

Dates	Institution
Oct 2017	Autonomous Cluster Fund **Park of innovative technologies** (Almaty Tech Garden), Almaty, Kazakhstan
Oct 2017	**Techno park Astana Business Campus**, Nazarbaev University, Astana, Kazakhstan
Oct 2017	**Science and Technology Park "Ertis"**, Pavlodar, Kazakhstan
Oct 2017	**MOST** Business incubator, Almaty, Kazakhstan
Nov 2017	**BSUIR** University Business incubator, Minsk, Belarus
Nov 2017	**Hi-tech park**, Minsk, Belarus
Nov 2018	Business incubator **AUC Venture Lab** Cairo, Egypt
Nov 2018	**The Greek Campus: FALAK Startups accelerator** Cairo, Egypt
Nov 2018	Business incubator **Kamelizer Technology** Cairo, Egypt
Nov 2018	Business incubator **Flat6Labs** Cairo, Egypt

The analysis of the situation in Kazakhstan and the guidelines provided in Russia (RVC, 2017) further highlighted a significant existing gap in the modelling and design of BI and how they should operate. The vast majority of literature on the subject focuses on econometric performances and so the definition and models, however, this is a partial (and potentially biased) view of the system especially as it focuses on the incubator residents rather than the incubator internal processes. This led to the investigation and development of a functional model that could describe the process and allow a performance analysis of it based on standard project management and engineering methods.

The proposed model is also informed of the *"ten principles of Cabral*" (Cabral, 1998a,b), the different business models reported in literature and most frequently adopted as per (Ryzhonkov, 2014) research

Literature Review

According to (Eisenbart et al, 2013), because the most important design decisions are made when conceptualising a technological system, a shared understanding among the system's engaged designers is critical. Furthermore (Eisenbart et al, 2013) states that *"system development increasingly requires the integration of different technologies, necessitating a closer collaboration of experts from different disciplines"*.

Most of sources agree that Business Incubators are widely recognized as ways of fostering innovation and as such represent a very interesting research topic. However, this is contested by authors such (Tavoletti, 2013) and is based on the analysis (in most cases) of econometric data rather than process efficiency and effectiveness. Possibly, the best analysis of business incubation performances benchmarking literature can be found in (Torun et al. 2018). The main outcome of this study can be summarise in the following table:

Table 2 – Process related benchmarks extracted and elaborated from (Torun et al. 2018) analysis

KPI	% in the literature	Reference Papers for the benchmark
Survival Rates (%)	58.5	Bhatli (2015); CSES (2002); Dichter and Marchand (2017); Knopp (2012)
Number of Incubatees	39.0	CSES (2002); Dichter and Marchand (2017); ECA (2014); Knopp (2012); OI (2006); The Evidence Network (2016)

KPI	% in the literature	Reference Papers for the benchmark
Size of Network (# of total connections)	31.7	Bhatli (2015)
Space (m2)	24.4	CSES (2002); OI (2006); Knopp (2012); Dichter and Marchand (2017)
Average Incubation Time (months)	24.4	Bhatli (2015); CSES (2002); Dichter and Marchand (2017); Knopp (2012); OI (2006)
Occupancy Rates	17.1	CSES (2002); Knopp (2012); OI (2006)
Average Annual Operating Costs ($k)	17.1	Bhatli (2015); CSES (2002); OI (2006)
Patents Granted (yearly)	14.6	Dichter and Marchand (2017)
Number of Spin offs/Start ups Created	14.6	Dichter and Marchand (2017); ECA (2014)
Number of Enquires per Year	14.6	Bhatli (2015); Dichter and Marchand (2017); ECA (2014); Knopp (2012); OI (2006)
Number of Staff	12.2	CSES (2002)
% of Managers' Time Advising Clients	9.8	CSES (2002); Knopp (2012); OI (2006)
Total Expenditure ($m)	9.8	Dichter and Marchand (2017); Knopp (2012)
Number of Projects (yearly)	7.3	ECA (2014)
Ratio of Tenants/Staff	7.3	CSES (2002)
Number of Enquiries Turned into Tenants per year	2.4	OI (2006)
Length of Setting Up (months)	2.4	OI (2006)
Number of Feasibility Studies	2.4	Dichter and Marchand (2017)

In (Torun et al. 2018) analysis is apparent that the survival rate is generally considered as the main relevant KPI to be used when assessing the BI performances, however, it is worrying the fact that the survival rate is not considered in conjunction with number of enquiry and the number of those turned into tenants. In (Ryzhonkov, 2014) analysis, is made clearly apparent the massive disparity between applicants and residents (around 1000 to 30-40 at most respectively), which point out the very low BI applicants' acceptance rate. If then the survival rate is low – Relan (2012), argues that 90% of start-ups may/will fail – then there is likely a correlation between the failure and the incubation process. Such a potential high failure rate is highly concerning, especially when taking into account that it is *"more efficient to kill ideas rather than companies",* and therefore it is far better not to *"spin a company out without traction"* Relan (2012). At the same time if only around 30-40 at most out of 1000 applicants are accepted, they should be the best with the best opportunity to succeed, yet, according to (Bone et al. 2019) *"until now relatively little was known about their impact on the startups they support and the wider business ecosystem".*

It is clear that not all ideas will be supported, and thus the selection procedure (which varies depending on the nature and focus of the BI) is the one that potentially differentiates the various business incubation effectiveness. The ratio between resident and applicants, in turn, highlights the system's administrative complexity which could be reduced but will not be eliminated by the establishment of Virtual Incubators as favoured by (Ryzhonkov, 2014). However, given the relative scarcity of funding and investment options compared to demand, the necessity for a comprehensive evaluation of submitted ideas in terms of merit and impact remains paramount.

It is arguable that the survival rate should be high if the selection process has been so strict and rigorous and only the best ideas have been selected. However, according to (CB Insights,

2021a, b), 35% of incubated companies fail because of lack of market need, 20% are out-competed, 19% have a flawed business model, 14% do not have the right team, 10% launch their product in the wrong time, 8% created a poor product, and 5% burned-out or lacked sufficient passion. These findings raise serious concerns on how the Business Incubator/Accelerator process is designed and implemented as per (Tavoletti, 2013), and further support the need for an adequate modeling focused on the process to identify the potential bottleneck and points of failure.

Several studies on BI dominated the first decade of the twenty-first century, owing to the fallout from the Dot-com boom and the need to help the economy recover quickly. Nowak & Grantham, (2000) presented the Virtual Incubation Model based on findings in the IT industry, stating that conventional business development entrepreneurs face common challenges: the lack of finance, people resources, and management capabilities. The goal of their concept is to provide a structure and mechanism for small businesses to quickly access knowledge on *"best practices"* industry and management experience, and resources for worldwide marketing, sales, and distribution. However, this strategy emphasises resource accessibility over the development process that may be required to transform a would-be entrepreneur into an actual and active entrepreneur.

In 2000, the UN published a very complete and detailed *"Technology Business Incubator Manual"* intended to guide planners, educators, sponsors and management teams in exploring and establishing a successful program (Lalkaka, 2000). The document has five parts, covering: *1) Incubation Concepts, 2) Planning, 3) Implementing, 4) Operating, and 5) what can be learnt from other previous experiences*. The aim in this case was operational, to guide whoever wanted to set up one such initiatives (although mostly aimed at governments and public institutions).

In 2004, (Hackett & Dilts, 2004a) addressed the BI modelling and developed a specific formulation of Business Incubator Performance:

$$\boldsymbol{BIP = f(SP + M\&BAI + RM)}$$ (Hackett & Dilts, 2004b)

where ***BIP*** stands for ***Business Incubation Performance***, ***SP*** for ***Selection Performance***, ***M&BAI*** for ***Monitoring & Business Assistance Intensity***, and finally ***RM*** for ***Resource Munificence***.

Slightly later, a World Bank Group program to promote entrepreneurship and innovation (InfoDev) developed and published, in the period 2010-2016, several materials that could be valuable for those who are creating business incubators. The process they adopt stresses the linkage between business incubation phases and entrepreneurial life cycle attempting to map the two one on the other. The possibility to keep relationship with [alumni] mature companies can be a crucial strategy to assist with and subsidize their other programs (InfoDev, 2010).

Ryzhonkov (2014) *"Generic Business Incubation Model"* is substantially a synthesis of the models available in literature that collect and combine the benefits of all of them. His analysis highlights that the incubation cycle has a duration that can be estimated vary between 3 months and 3-5 years, depending on the sector, the type of the incubator, and capacity of the proposed activity, the profile of the businessman and his team and the evolution of the project activity itself. However, while Ryzhonkov (2014) is a clear improvement with respect to the previous models, it does not yet solve the low acceptance rate nor the potential wrong candidate choice. This why the present research attempts to exploit tools and practices used for quality assurance and process control optimization as per (Speyer & Jacobson 2010) or (Mesterton-Gibbons, 2009) to derive a flexible, adaptive model of the incubation process operation that can be used to streamline resource management and optimize the process based on execution and output feedback while taking into account the operation context. This choice is grounded and

supported by the findings of (de Bem Machado et al., 2017), that the models reported in literature describe the business incubator as a transformation mechanism without making explicitly better management practices for the continuous improvement of the incubated enterprises. This is also pointed out by (Ryzhonkov, 2014) when analysing (Hackett & Dilts, 2004) model and suggested by Medibtikar Project onnnovation and technology in 2012, when stressing the need for a constant attention to service provision and management as well as to the Plan-Do-Check-Adjust (PDCA) cycle (cited in Ryzhonkov, 2014), which ultimately implies paying attention to process quality as per ISO9001, ISO21500, TQC,6 sigma, etc.

Methodology

As already reported in a previous paper, in order to ensure feasibility of our research on a domain that is extensive and has been researched for a number of years from very different perspectives, we have adopted an integrative review approach (Jones-Devitt et al. 2017) with respect to Business Incubation and to General Management.

Of the 663 resources listed in Scopus, we consider only the Open Access ones, thus, as inclusion criteria we considered articles/papers/reports/studies/sources that were fully accessible and fully matched the search criteria, while as exclusion criteria we considered articles, papers, reports, studies, and sources that could not be fully accessed, or were too dated, or did not fully matching the search criteria. Given the rather limited sources available on open source and the lack of funds to access the paid ones, it was deemed as a valid alternative to use Google Scholar, provided each item identified as interesting was checked in terms of provenance and reputation of the source.

Table 3 - Systematic results of the literature and sources search

Search term(s)	Identified		Selected	Used
	GS [2]	S [3]		
"Business Incubator" AND definition	23 [4]	15	14	4
"Business Incubator model"	316	7	13	4
"Business Incubator business model"	13	1	13	5
"Business Incubator performance"	243	9	16	4
"Business Incubator" AND efficiency	5 [5]	38	14	4
"Business Incubator" AND effectiveness	36 [6]	64	16	4
"Business Incubator" AND metrics	2 [7]	5	11	4
"Business Incubator" AND "Key Performance Indicator"	127	2	16	5
"Information Management System" AND "Business Incubator"	54	0	11	4
"Information Management System" AND "Science Park"	174	2	17	1
"Business Incubation" AND "systematic review" OR "literature survey"	407	4	17	5
"Business Incubator" AND "systematic review" OR "literature survey"	408	7	13	4
"Business Incubator model" AND "systematic review" OR "literature survey"	52	0	10	4
"Business Incubation model" AND "systematic review" OR "literature survey"	48	1	4	1
			185	**53**

[2] Google Scholar

[3] Scopus

[4] The search has been repeated using *"Business Incubator definition"* to reduce results from the 15400 originally identified

[5] The search has been repeated using *"Business Incubator efficiency"* to reduce results from the 13100 originally identified

[6] The search has been repeated using *"Business Incubator effectiveness"* to reduce results from the 15400 originally identified

[7] The search has been repeated using *"Business Incubator metrics"* to reduce results from the 2910 originally identified

Given the wide range of business incubation models and definitions – see (Ryzhonkov, 2014) for the models and Appendix 1 for the definitions – it was decided that an inductive approach within the context of an Interpretivist research philosophy would be most useful. During the investigation, it was also discovered that there is a considerable reluctance to share information about specific areas of the programme, such as resident failures, regardless of whether it is during or soon after completion. This suggests a desire to avoid a detailed examination of performance, in accordance with (Tavoletti, 2013), and it reinforces the authors' conclusion that improved ways to comprehend and manage the process are required to help both prospective residents and investors.

Better data management could lead to a more accurate evaluation of the efficiency and efficacy of business incubators. As a result, the proposed model was developed using a descriptive approach based on various reports and case studies, as well as direct involvement (by direct observation) in the launch of new BIs, interviews, and a small survey in a few Business Incubators. The findings will be used to guide the next steps, which will involve a survey and heuristic evaluation of the proposed strategy, measurements, and KPIs.

Analysis of the process

Based on the analysis of the models identified in literature and the information collected first hand, the process is presented using standard *"Work-Flow Diagram"* notation (ISO 9001:2015) while the model uses *"Control Systems Theory"* notation in the attempt to describe the process, and its components, using a formal approach that could provide a general view and description of how business incubators work irrespective of their business model.

In Figure 1 are sketched the process that leads to the launch and operation of a business incubator or accelerator. The diagram highlights the point of control/decision and the steps that require *"particular"* attention (as they pose a challenge to the successful implementation or execution of the business incubator program).

Each step in the process has been assigned a label and an identifier so as it can be easily referred to. In Appendix 2 are reported the description of the various steps along with the related challenges (where relevant) based on the outcome of the analysis of the conducted interviews, the literature, best practices and case studies as well as informed of the ten principles of Cabral and the various guidelines for implementation released by the EU, InfoDev and other relevant institutions.

In terms of major issues characterising the process, the first challenge is the design of the overall system (i.e. selecting the business model, format, etc.). This is clearly evidenced by the number of business models reported in literature.

The second is the selection of suitable location, key personnel and program design (especially for a privately own BI) as this may determine the success of the initiative or its failure. It is worth noting that in the program design attention is placed to the intended audience as this will determine if the BI will be covering a specific vertical(s) or a transversal approach to innovation.

The third is the acquisition of the resources (especially for a privately own BI). If these major obstacles are overcome and the program is ready – at least as concept – it is possible to start the promotion and activate the launch which will run in parallel at least for a certain period. The next challenges will be the programme promotion and the selection of the candidates respectively.

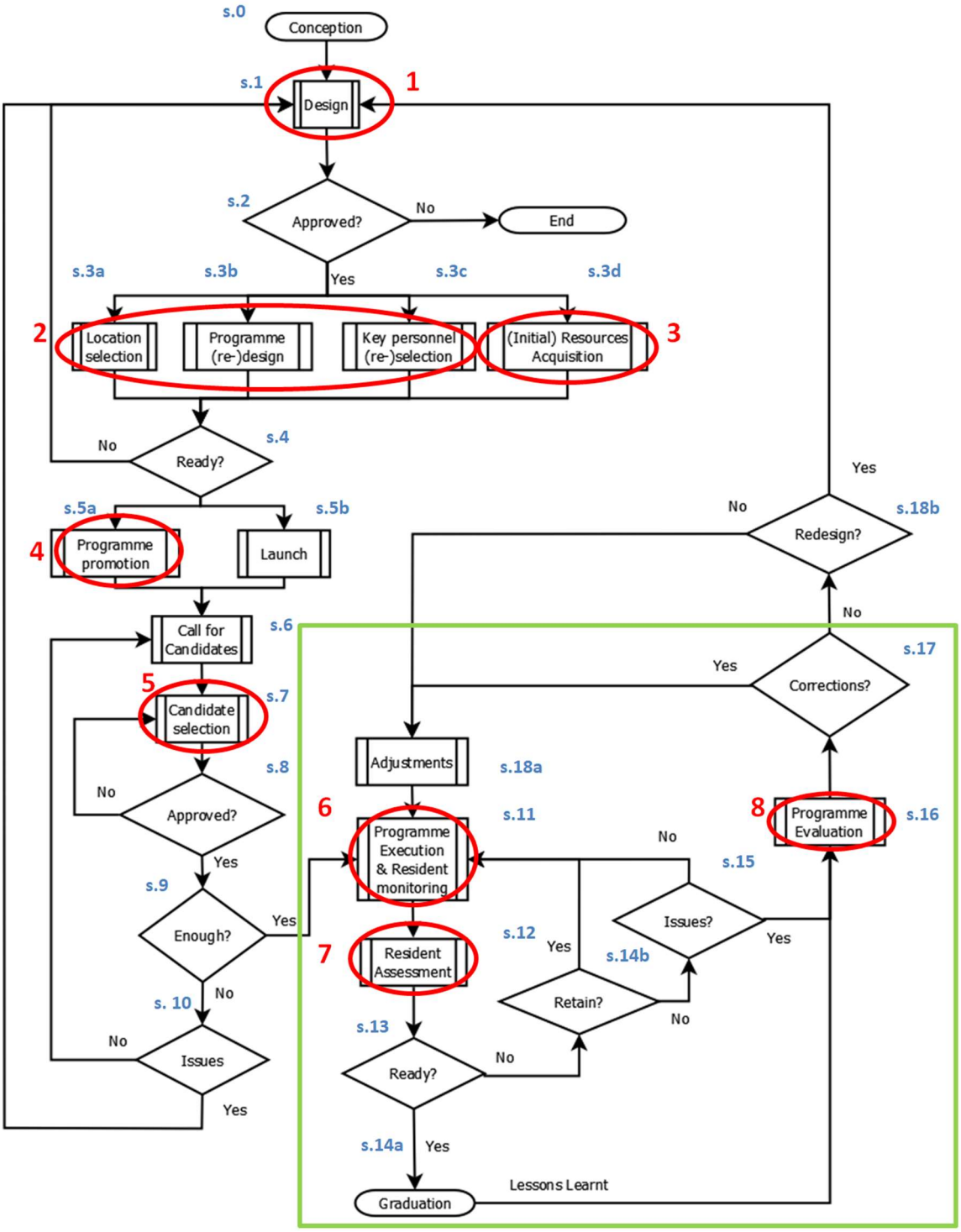


Figure 1 - BI development and operation process steps (general view)

These phases are critical as the availability and choice of the right candidates will largely impact the chances of success of the system in accomplishing its mission as well as in the possibilities for the candidates to successfully start-up their business as extensively stressed in literature.

The selection should be based on a mix of principles ranging from the quality of the idea (and the underlying business model) to its fit into the logic and ethos of the business incubator / accelerator / science park (Hacket & Dilts model, 2004).

The next crucial step will be the program execution. If the program is not well designed, or if the involved personnel are not up-to-the-level, or if the program is not well run results will not

be positive. This will be evidenced partially in the assessment of residents' performances and readiness to graduate. Therefore, it would be advisable to run a periodic program evaluation – based on the lessons learned with each graduation – as well as in case of issues in residents' assessment results and feedback. Understanding the process is crucial to its modelling, therefore the following sections focus on the description and analysis of the processes that underpin the proposed model.

From the overall process to the model

The Business Incubator process previously described covers all aspects from conception to execution as well as its evolution in time, however, in order to measure, analyse and improve its outputs (graduated companies), it is necessary to focus on the program execution.

To do this is necessary to first perform an analysis of the process that describes the creation and evolution of a company and compare it with what happens in a BI. This is best achieved with a Petri-net and its simplest form (see image aside) comprises 5 stages, namely:

1) Conception [A],
2) Proof-of-concept [B],
3) Prototype development [C],
4) Minimum-Viable-Product (MVP) [D],
5) Operation [E].

When looking at the process from the point of view of the resident, it is possible to appreciate that Ideation occurs before Incubation (pre-Incubation phase) on the one hand. On the other, from the point of view of the Incubator/Accelerator, quality and viability (along with the perceived/proposed profitability) will be the main selling point of the applicant at the time of application.

This is an important aspect as per (Relan, 2012) observation that not all ideas will have traction, thus if applicants approach BI when they have already developed some kind of proof of concept their chances highly increase.

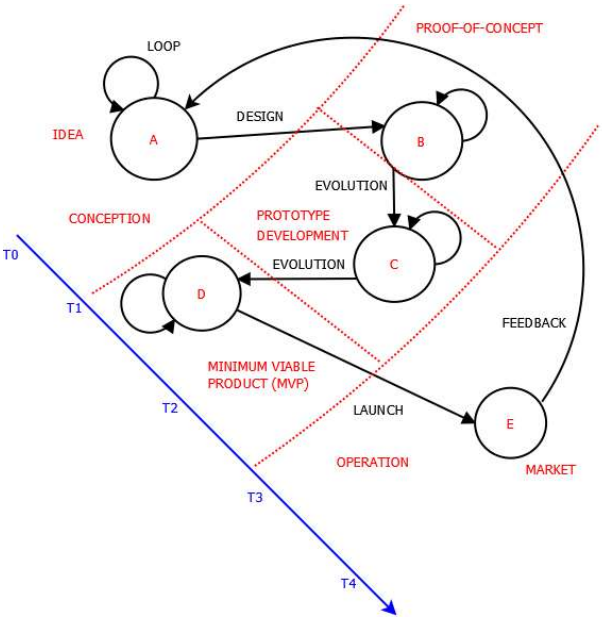


Figure 2 - From Idea to Market as state machine

The experience gained in every step can be fed back and spark new ideas and improvements, which can be injected in the project and its outputs (including new products). To this extent, in the diagram can be noted the feedback loop and several auto loops which are showing that new concepts can be suggested in every stage by by testing as well as by customers' / early-adopters' feedback.

This approach, however, points out the complexity of the system and it is worth recalling that increased complexity can create dangerous vulnerabilities (Bonabeau, 2007). The feedback could simply imply bug-fixing or re-work but also the sparking of innovative ideas. The evolution of a proof-of-concept into a research prototype and then an industrial prototype is underpinned by a huge potential for innovation thanks to the lessons that can be learned.

The Alpha-version is often used with some early adopter that are willing to take up the risk to test in the real world the MVP and feedback their experience and advice so as to not only improve the product but fast-track its evolution to the Beta-version and eventually the commercial 1st series (Huh & Kim, 2008).

In terms of workflow (as depicted in Figure 3 and detailed in Appendix 3), if we were to ignore two stages (that is Initial Training and Further Training); this process applies to any company and expands what presented by (Adler et al., 1996).

Taking into account PRINCE2, projects are how businesses achieve/introduce change in what is their business as usual operation, therefore if we consider a start-up or a company embracing some innovation (new products or services design, restructuring, expansion, etc.), then both Initial Training and Further Training would perfectly fit in the process too.

Given the way Business Incubators work – that is in batches or cohorts – it is possible to argue that each Resident is equivalent to a project in a Portfolio or Program. This similarity (defined start & end, specific scope and objective) offers the possibility to use Earned Value Management (EVM) as the elective tool to monitor performances of the Resident and – ultimately – of the BI. As EVM compares planned versus actual costs as well as planned versus actual value generated, it is necessary to describe the entire system in monetary terms including the external factors that affect the system overall.

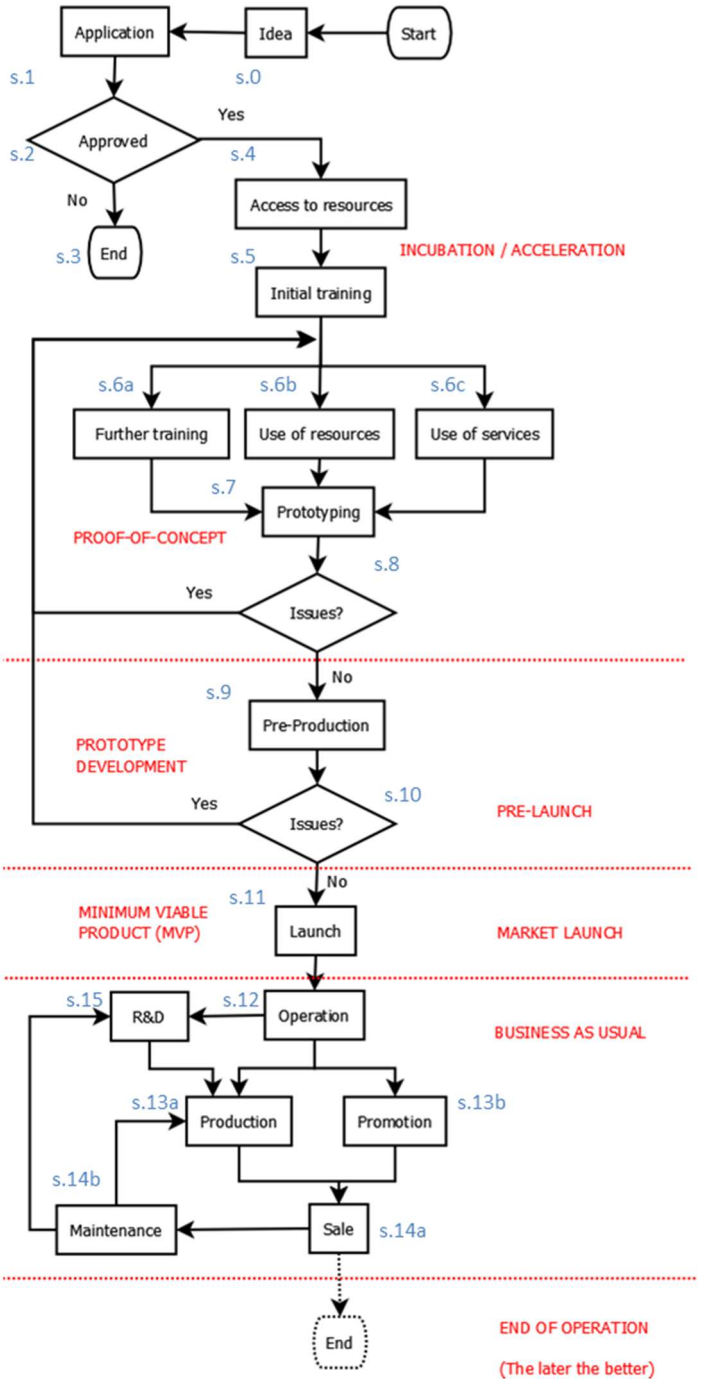


Figure 3 - From Idea to Market taking into account the BI program execution as workflow

The functional model

Based on the previous description, what follows is a functional control model of the incubation program execution based on the overall discussed process. The proposed functional model presented in *Figure 4* using control theory notation can be analysed in terms of flux of information for decision making taking into account that the system has some inertia.

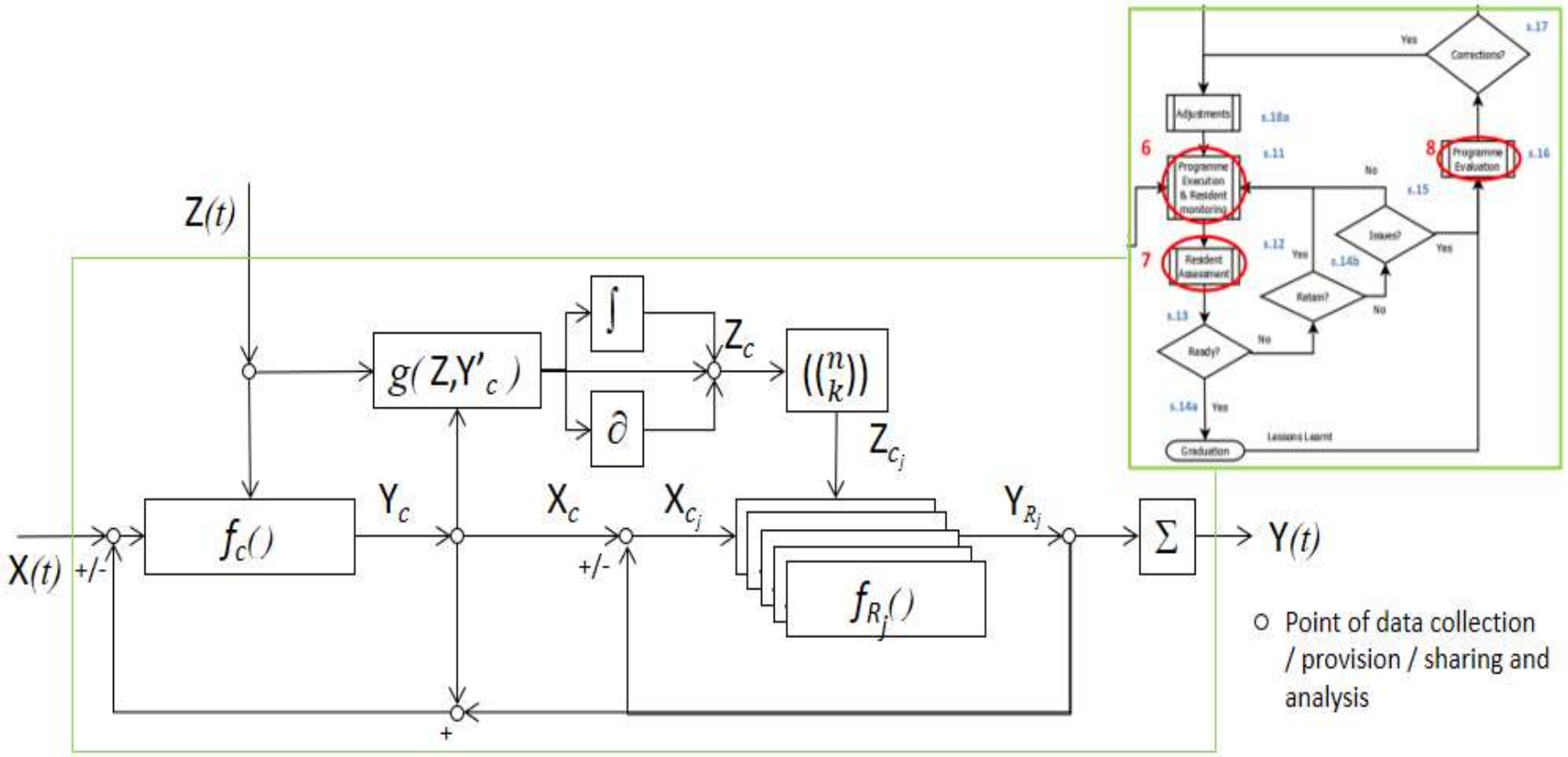


Figure 4 - BI program execution and Residents' monitoring & assessment functioning

The diagram refers specifically to the steps s.11, 12 and 18 of the process previously presented (see Appendix 2) and has been designed taking into account the data collected in the interviews, the current best-practices (reported in the analysed EU, UK, Belorussian and Russian reports) and the analysis of current issues and shortcomings encountered in business incubators and science parks (as highlighted by various consulted EU and Russian reports).
In the diagram are highlighted the points of data collection/provision and analysis as well as the points of data sharing. The external factors and conditions are represented here as parameters that influence directly the system control and – through a mediated approach – the residents and their operation. The mediated approach attempts to simulate the kind of interventions BI / BA perform when supporting/shielding the residents from the external circumstances. The outputs of the residents are not only the overall output of the system but are also used to provide precious decision feedback influencing the overall operation of the system.
Unlike in a control system, the feedback is taken into account in discrete moments and not continuously. We used EVM given the project-nature of the Residents' operation and assumed a periodic monitoring of results which require some time to occur (time interval that depends and varies according to overall duration of the Residents' programme). The chosen approach is reflecting the need for the system to evaluate and monitor the applicants but also account for any required adjustments as well as own performance, efficiency and effectiveness.
The need for measuring is part of any quality approach as only by comparison is possible to assess if objectives have been reached as well expressed by Lord Kelvin assertion *"to measure is to know" ... "If you cannot measure it, you cannot improve it"* (cited in Ryan et al., 2009, page 5). This in turns raises a question on how, where and what data needs to be collected and used to create a baseline and measure subsequent changes ultimately monitoring the quality of the process. Using a *"control system"* approach, the various aspects of the system are presented and the related variables (inputs, outputs, and parameters) described in terms of relative dependency and influence to support managing the operation of a business incubator/science park.
Although *'standard' control system block diagram* approach is used, the transfer and control functions that describe each component depend on a variety of inputs and parameters that goes well beyond the standard Proportional, Integrative, Derivative (PID) as will be apparent later on, additionally, several assumptions have been made in order to keep the whole model simple enough and practically manageable.
As the first and strongest assumption, it will be assumed that the relation between input and output of the functions $\boldsymbol{f_C}(\,)$ and $\boldsymbol{f_{R_j}}(\,)$ is in the form $\boldsymbol{y = A\,x - B}$ which implies a direct dependency of the output from the input (although the latter is influenced by the external parameters). The minus sign is intended to represent the initial start-up indebtedness.
Secondly, it is assumed that the system operates in a *"discrete"* mode with respect to time. That is, the output at time $\boldsymbol{t+1}$ depends on the input at $\boldsymbol{t}$.
Additionally, it is assumed that in the observation period leading to the new input provision the external parameters – represented with $\boldsymbol{Z(t)}$ – will remain (reasonably) constant as it is usually done in planning and scheduling. Needless to say that in the model, the observation period (described by $+\mathbf{1}$) has to be commensurate with the duration of the program. This implies that the observation period requires to be adapted to the process and may be shortened if observation shows excessive variability between what expected and what observed.
The output $\boldsymbol{Y(t)}$ of the system is represented by the Products/Services generated (inclusive of the related intellectual capital, revenues and dividends), while the system inputs $\boldsymbol{X(t)}$ are the external investment, capital and resources that can be acquired/procured by the BI. All expenses are part of the equation and represent conditioning factors of the system operation as they depend on the legal settings, operation market, required infrastructure, nature of the

product/service produced, personnel, logistic & supply chain, R&D, etc. and consistent with the usage of EVM for the monitoring and controlling of the system.
By splitting down the various elements and then describing their relations, it is possible to derive a simple, yet functional, representation of the system and its functioning which can then be used in the overall model in terms of the $f_C()$ and $f_{R_j}()$. Overall, it is possible to establish linear dependencies between some of the elements; for example tax is proportional to income, income is proportional to sales and incomes is related to revenues by a known relation. Debt interests are proportional to subscribed debt, dividends are proportional to profit, salaries are composed with fixed portions related to market, characteristics of the employee, level of employment, etc. All these relations are linear or well-known and therefore can be modeled fairly easily. As all of them relate to monetary values and can be connected to both the prevision and actual budget, the usage of EVM provides an invaluable tool for forecasting and analysing performances (efficiency) as well as effectiveness of the system. It is worth pointing out that while EVM will be extensively used ad referred to, it is not explained here but can be found in (APM, 2013; Lipke et al. 2008; Vanhoucke, 2009).

Table 4 - Meaning of the symbols used in the model

$g(Z, Y'_C)$	The approach adopted for managing the way BI parameters and business model affect residents' parameters inclusive (but not limited to specific support measures and services offered to the residents)	m	The number of residents present in the BI
$f_C()$	The operation model of the BI which is affected by the differences brought by different BI business models as well as local context, covered sectors etc.	$\binom{n}{k}$	Any combination of k factors among n possibilities applied to the residents' choice of the support & services available as part of $g(Z, Y'_C)$
$f_{R_j}()$	The operation model of the generic resident **j** which depends on the business model adopted by the resident $\forall j \in \overline{1, m}$	X	Input to the BI: the set of Income, Resources, Staff, Connections available
Y_C	The output of the BI control system is the actual input to the resident and if defined by BI business model as described by $f()_C$	X_C	The overall possible input to all resident as coming from the BI control system $X_C := Y_C$
X_{C_j}	The input to any of the m residents which depends on the choice each resident will make based on needs and availability $\forall j \in \overline{1, m}$	Y	Output of the BI or the sum of the outputs of the m residents, that is: $Y_C = \sum_{j=1}^{m} Y_{R_j}$
Z	Parameters influencing the BI, that is available mentors, economic, political, cultural, legislative, technological context (*). Given that all parameters in the set depend from t it is reasonable to say that $Z := Z(t)$, in other words: $$Z(t) := \{P_C, E_C, S_C, T_C, L_C, C_C, M_C, t\}$$ where: P_C The political context in which the BI operates (considered constant in most cases) E_C The environmental context in which the BI operates (considered constant in most cases) S_C The socioeconomic context in which the BI operates T_C The technology context in which the BI operates L_C The legal context in which the BI operates (considered constant in most cases) C_C The cultural context in which the BI operates (partially included in SCI partially considered constant) M_C Market context(s) the BI addresses		
Z_C	The parameters influencing any of the m residents and that are a combination of the BI parameters and outputs of its control system, their variation in time and their cumulative history including the lessons learned as per output of $g(Z, Y'_C)$.		
Z_{C_j}	The parameters influencing a specific resident (j in this case) and that are relevant to the specific resident his different needs and business model.		

(*) see GEM country profiles and data (GEM, 2016; GEM, 2017; GEM, 2018)

Business Incubators can support their Residents providing training, mentoring, coaching, services, funding and access to investors, as well shield the residents from external factors (at least to a certain extent). The latter point is achieved using countermeasures and – in case –

exploiting contingency funding/measures to counter/mitigate the negative impact of external changes or to provide supplementary training/equipment to enable exploiting emerging opportunities. This has been represented in the model using $\boldsymbol{Z_C}$ which is the output of $\boldsymbol{g(Z, Y'_C)}$ or in other words the BI approach to counter/support the impacts of the PESTL+CM external factors. It is important to note that it has been decided to combine the Economic and Social aspect into a Socioeconomic one and add a Cultural aspect to better exploit the data provided in the GEM country profiles and data (GEM, 2016; GEM, 2017; GEM, 2018).
Just like for the inputs $\boldsymbol{X_C}$, the residents are then able to select a combination of contingency measures that are, in the Residents' view, the most suitable for them and this is why a combinatory approach has been used to describe $\boldsymbol{Z_{C_j}}$. The contingency measures that can be provided are several, however, given the reported nature of $\boldsymbol{Z(t)}$, the contingency measures have been divided in four groups reported hereafter. Each has been assigned a reference preferred value range with respect of the overall available contingencies based on the collected evidence and assuming all elements will be present at the same time, however, a BI will be able to select the most appropriate value depending on their specific circumstances. Therefore, reported values are purely indicative although based on observation and the data available on GEM for the nations considered in the research at the time of writing but will be updated and adapted consistently for use in a different setting or time.

Table 5 – Indexes and intervention measures used in the management of the external parameters

Index	**Support *Measure***	**Range of support (*)**
$\boldsymbol{EII \Rightarrow SES}$	SocioEconomic Support	0-50%
$\boldsymbol{SCI \Rightarrow ETS}$	Education & Training Support	0-15%
$\boldsymbol{MPI \Rightarrow MPS}$	Market Performance Support	0-20%
$\boldsymbol{TMI \Rightarrow TMS}$	Technology Market Support	0-15%

(*) Expressed as a percentage of the available Contingency Fund

From the table is clear that each Intervention is connected to a measure of an external aspect that may affect the Resident's development process. The way these factors have been represented and can be computed is reported in the following table.

Table 6 – Indexes used to determine the intervention measures used in the management of the external parameters

Index	**Index formulation**	**Notes**
Economic Indicator Index	$\boldsymbol{EII} = \frac{\boldsymbol{GDP(t) - GDP(t-1)}}{\boldsymbol{GDP(t-1)}}$	Expressed in terms of the variation of GDP occurred between the current $\boldsymbol{t}$ and previous $\boldsymbol{(t-1)}$ period of observation
Socio-cultural Indicator Index	$\boldsymbol{SCI} = \frac{\boldsymbol{ALI(t) + DLI(t) + FLI(t)}}{\boldsymbol{3}}$	where ALI is the Adult Literacy Index, DLI is the Digital Literacy Index, and FLI the Financial Literacy Index (*)
Market Performance Index	$\boldsymbol{MPI} = \frac{\boldsymbol{SCM(t)}}{\boldsymbol{GDP(t)}}$ %	Corresponding to the % of the GDP represented by the Market Capitalization of the Listed Domestic Companies and available as a World Bank Statistics
Technology Market Index	$\boldsymbol{TMI} = \frac{\boldsymbol{TRDS(t)}}{\boldsymbol{GDP(t)}}$ %	Corresponding to the % of the GDP devoted to the Global R&D Spending and available as a World Bank Statistics

(*) As far as computing these values, it is worth noting that there are not specific, globally accepted statistics for what concerns the Digital Literacy, however it is possible to extrapolate data from the available statistics (either global or national) while there is a UNESCO proposal for the definition of a global framework to measure digital literacy (Antoninis & Montoya, 2018). As far as Financial Literacy is concerned, it is possible to use the OECD data (OECD, 2019).

There may be sudden changes in the external factors that require an almost immediate intervention (represented with $\boldsymbol{Z_C(t) = c_f\,[Z_C(t-1) - Z_C(t-2)]}$ where $\boldsymbol{c_f}$ stands for a ***Contingency Factor*** selected by each BI depending on their needs & structure) which may

combine with the planned intervention approach ($Z_C(t) = SES + ETS + MPS + TMS$) and the sum of interventions occurred up to that event (represented with: $\int Z_C(t) = (TMS + ETS)$). The way the external factors and the BI control function outputs are combined in order to support the residents depend in large measure from the business model adopted by the BI, its nature and the sources of funding. These parameters depend also on the number of residents already present at the moment and are used in combination with the information available on the functioning of the system. When analysed in conjunction with the insights provided from the metrics being collected, it is possible to fine-tune and adapt the inputs available to each of the m residents. The most important thing to consider is that the variation of external parameters (in terms of trend) and the variation in feedback are the criteria to be used in shaping the way external factors moderate the functioning of the system. The needs of the generic resident have been considered and are expressed as:

$$N_{R_j} := \{LO, RE, SE, TR, FU\}$$

where:

Table 7 – Residents needs representation

LO	***Location***	start-ups need a location where to be registered and operate, getting a commercial space is costly and often not easy
RE	***Resources***	start-ups requires - at least potentially - equipment to use for their daily work, research and development, etc.
SE	***Services***	in the start-up phase there are many services that are required - from accounting to legal support, from payroll to stock and procurement management - and that could be not only rather expensive - in terms of tools acquisition - and potentially complicated in terms of learning curve
TR	***Training***	depending on the background of the funder(s) there may be a number of training needs to be fulfilled
FU	***Funding***	ideas are essential but to make a business, but they are not enough as there are a number of expenses to be faced and recurring costs to be covered, this implies access to financial resources which may be not available or only partly available

The input in the system can be considered as the overall income for the BI (from a monetary approach) and is proportional to the intersection between socioeconomic and the technology context (and its variations) as this is what drives the investments in technology. The proportionality relation depends also on the intuition and intentions of the investors backing up the BI.

$$I_{BI} \propto \{S_C \wedge \partial S_C\} \cap \left\{\{T\_C \wedge \partial T\_C\} \wedge \{\{M_C\} \wedge \{\partial M_C\}\}\right\}$$

$$X(t) := I_{BI}(t) \cup \left\{C_{BI}, E_{BI}, R_{BI}, S_{BI}, M_{BI}, \{N_{Rj}\}, t\right\} \quad \forall\, t \in \overline{t_0,\, T_C}$$

Table 8 – Indexes and intervention measures used in the management of the external parameters

C_{BI}	Connections of the BI with industry, investors, Business Angels, Venture Capitalist, Funding Bodies, etc.	E_{BI}	Expenses of the BI: capital, fees, services, personnel, utilities, insurance, etc. including one-off expenses
R_{BI}	Resources of the BI: premises, equipment, facilities, etc.	I_{BI}	Income of the BI: capital, fees, services, donations, grants, etc. including one-off sources
S_{BI}	Staff of the BI (inclusive of their know-how, experience, etc.)	M_{BI}	The set of mentors that interact with the BI and provide services to it
N_{R_j}	The needs of any of the **m** residents	∩	The ***"Union"*** operator
∧	The ***"AND"*** operator	∨	The ***"OR"*** operator

The way capital and resources (included human ones) are provided to a BI depend largely on the property and model underpinning the BI itself. If it is private rather than state own or with mix ownership in times of recession or economic difficulty the amount of capital provided to

the BI will change depending availability but also purpose and expectations. This is apparent when noting that the first BI was launched to make use of unused resources and thus reduce costs associated to unused property rather than favour potential entrepreneurs. If the property is private, investment will continue until the operation is profitable and/or gives results and/or provides a viable way to reduce the tax load (this does not apply to all countries though).
The overall set of inputs available to a generic Resident $\boldsymbol{j}$ depends on the outputs of the BI control function, the needs of the residents and the feedback of the overall system. It is also clear that if there are $\boldsymbol{m}$ residents, therefore, the resources quantity available to each is inversely proportional to the number of residents. It is also necessary to take into account that the relevant inputs are those that intersect with the needs and their evolution as portrayed by the output of the residents themselves. This brings to light a further aspect that relates to the fact that despite being mentored and coached, the resident are independent potential entrepreneurs that may take/drop the received advice and training and perform a selection of the offering input, in other words:

$$\boldsymbol{X_C \propto \frac{1}{m}\{Y_C \wedge \delta Y_C\} \cap \left\{\left\{N_{R_j}\right\} \wedge \left\{\left\{Y_{R_j}\right\} \wedge \left\{\delta Y_{R_j}\right\}\right\}\right\} \quad \forall j \in \overline{1,m}}$$

Any potentially unmatched need can be described as the difference between the received input (based on the operated selection of the available inputs) and the resident's needs due to the unavailability within the overall offerings available within the BI, in other words:

$$\boldsymbol{\sum_{j=1}^{m} X_{C_j} \subseteq X_C := Y_C}$$

$$\boldsymbol{\sum_{j=1}^{m} X_{C_j} \subseteq X_C \Rightarrow \Delta N_{R_j} := \left\{N_{R_j}\right\} \notin \sum_{j=1}^{m} X_{C_j} \subseteq X_C}$$

The initial input in the system – or its initial capital – can be described as follows:

$$\boldsymbol{X_0 := \{SC_0 \wedge LV_0 \wedge EC_0 \wedge PC_0 \wedge IC_0 \wedge TMC_0 \wedge CMC_0 \wedge OC_0\}}$$

where:

$\boldsymbol{SC_0}$	***Seed Capital***	The money put as seed capital for the residents in the incubator/accelerator (if present)
$\boldsymbol{LV_0}$	***Location Value***	The value of the BI location if purchased (and thus part of the capital as asset)
$\boldsymbol{EC_0}$	***Equipment***	The value of the initial set of equipment purchased for the BI (and thus part of the capital assets)
$\boldsymbol{PC_0}$	***Personnel***	The cost of acquisition and retention of the personnel for the first year of operation (including start-up)
$\boldsymbol{IC_0}$	***Infrastructure***	The value of the initial infrastructure purchased for the BI (and thus part of the capital assets)
$\boldsymbol{TMC_0}$	***Training material***	The cost of the training material purchased or licensed for usage within the BI and acquired at $\boldsymbol{t_0}$
$\boldsymbol{CMC_0}$	***Consultancy & Mentoring***	The costs incurred to interact with and acquire services from external consultants
$\boldsymbol{OC_0}$	***Other capital***	All the other capital components that have been set aside for the BI

The assessment of results is based on the comparison of $\boldsymbol{Y(t)}$ with $\boldsymbol{Y(t)_{Expected}}$ [8]. Using Earned Value Management and having defined all the relevant components, it is possible to describe the functioning of the system in terms of the transfer functions applied.

$$\boldsymbol{f_C(\,) \;\Rightarrow\; Y_C(t+1) := f\left(\left\{\int_0^t (I_{BI} - E_{BI})dt \cup R_{BI} \cup S_{BI} \cup C_{BI}\right\}, \left\{N_{R_j}\right\}, Z(t), Y_C(t), t\right)}$$

The output of the BI control transfer function depends on time, inputs, resources, available staff and contacts, external factors and resident needs. The financial aspects are determined by the balance between the income – of all nature – and the expenses. The resources available include but are not limited to premises – offices, meeting & classroom, equipment, canteen, etc. The staff and contacts are also extremely important assets that can determine the success or failure of the BI. External factors include those typically encountered in a *PESTL* analysis plus the *Cultural* ones. In our notation the $\boldsymbol{E}$ in ***PESTL*** stands for ***Environmental*** and the $\boldsymbol{S}$ for ***Socio-Economic***. This convention has been used here to avoid repetition of letters with different meaning within the formulas. The function takes into account the feedback coming from the entire system (the resident as well as the BI control system), that is:

$$\boldsymbol{f_{R_j}(\,) \Rightarrow\; Y_{R_j}(t+1) := f\left(\left\{X_{C_j}(t) \cup Z_{C_j}(t)\right\}, \left\{N_{R_j}\right\}, Z_C(t), Y_{R_j}(t), t\right) \qquad \forall\, j \in \overline{1,m}}$$

The output of the generic resident system is structurally similar to the one of the BI control system (being both a company) and is a function of time, available (and selected) inputs, resources, available staff and contacts, external factors and own needs. The financial aspects are determined by the balance between the seeding fund and services acquired that require the payment of a fee. The resources available include but are not limited to assigned premises spaces for offices, meeting & classroom, equipment, canteen, etc. The availability of mentors and admin/technical support via BI staff as well as the potential access to contacts such as venture capitalist, investors, business angels, etc. are also extremely important assets that can determine the success or failure of the resident business project. External factors are mediated by the BI overall functioning system. Also, in this case, the function takes into account the feedback coming from the achieved performance thanks to the collected metrics and data.
The control parameters applied to each resident depend on the overall BI parameters, the approach adopted for managing the way BI parameters and business model affect residents' parameters, the variation in time and the cumulative effects of all these parameters and the BI business model. Further aspects to consider are the feedback received by the BI from the residents, the BI own reflection on performances and the performances of each resident. Performances are considered a crucial component of the individual transfer function model.

$$\boldsymbol{Z_C := \left\{g(Z, Y'_C) \wedge \left[\int_0^t g(Z, Y_C)d\tau \;\vee\; \partial g(Z, Y_C) \vee \left[\int_0^t g(Z, Y_C)d\tau \;\wedge\; \partial g(Z, Y_C)\right]\right]\right\}}$$

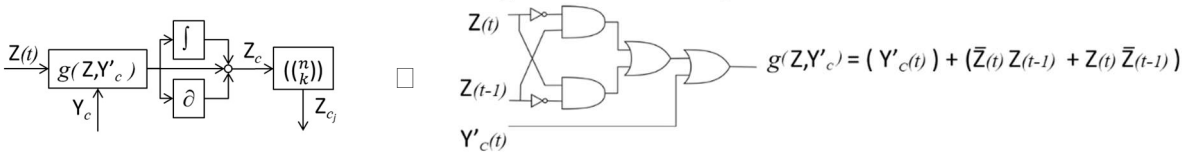
in which we have that:

$$\boldsymbol{g(Z, Y'_C) = f\left(Z, \frac{dY_C}{dt}, m\right) \;:\; B^3 \to B}$$

[8] Please note that $\boldsymbol{Y(t)_{Expected}}$ will be defined by each BI /BA based on the analysis of the resident application, usually in terms of economic ROI, therefore it is not modelled here.

where $B = \{0, 1\}$ in other words, $g(\,)$ is a Boolean triadic function that triggers the usage of the contingency funds available to compensate for external factors impacts which operates as reported hereafter.

Figure 5 - Functioning of the external parameter management



In Figure 5, is shown the way the model takes into account the external parameter based on what observed in the studied BI and available in the various guidelines. Substantially, $g(\,)$ operates as a trigger that activates the adoption of contingencies measures that are then put in place to support the residents.

When considering Earned Value Management, the related variables defined beforehand and the formulation of the various transfer functions, we have:

$$f_C(\,) \Rightarrow Y_C(t+1) = \alpha A_C(t) X(t) - \beta E_{BI}(t) - \sum_{j=1}^{m} RR_j(t)$$

Given the fact that on average:

$$A_{C_j}(t) = \frac{\alpha}{m} E_{BI}(t) \quad \forall j \in \overline{1, m}$$

$$X(t) = I_{BI}(t)$$

as all its human and physical resources will depend, ultimately, on the available financial resources. Once making the various substitutions the average output of a resident j has the following formulation:

$$Y_{C_j}(t+1) = \alpha \frac{1}{m} E_{BI}(t)\, I_{BI}(t) - \beta \frac{1}{m} E_{BI}(t) - RR_j(t) \quad \forall j \in \overline{1, m}$$

In this context the last term on the right side of the equation represents the impact of the feedback coming from the analysis of the Residents' performances as per model and has been labelled as RR that stands for ***Residents Remedial/Requests*** and represent the intervention planned to cover a performance problem or cater for a non-planned (yet approved need of one/several resident(s) that will be included in the BI expenses in the following reporting period and as such needs to be accounted for in a budget revision). RR can be easily formulated in terms of EVM, that is:

$$RR_j(t) = AC_j(t) + \frac{BAC_j(t) - EV_j(t)}{CPI_j(t)\, SPI_j(t)} \qquad \forall j \in \overline{1, m} \wedge \forall t \in \overline{t_0, T_C}$$

Where for each resident j, AC_j stands for ***Actual Costs***, BAC_j and EV_j stands for ***Budget At Completion*** and ***Earned Value*** respectively, CPI_j and SPI_j stand for ***Cost Performance Index*** and ***Schedule Performance Index*** respectively, t_0 stand for the time of entry in the BI / BA programme and T_C for the time of completion of the programme.

In case the external circumstances have not changed, it can be assumed that RR_j will be simply be equivalent to $Y_C(t) - Y_C(t-1)$ or, in other words, to consider that the feedback is simply a response to Residents' performance. Given the previously provided definition for $g(\,)$, it is necessary to compute the derivative of $Y_C(\,)$ with respect to time. This leads us to:

$$Y'_C(t+1) = \alpha\frac{1}{m}E'_{BI}(t)\,I_{BI}(t) + \alpha\frac{1}{m}E_{BI}(t)\,I'_{BI}(t) - \beta\frac{1}{m}E'_{BI}(t) - RR'_j(t)$$

with

$$I'_{BI}(t) = I_{BI}(t) - I_{BI}(t-1)$$
$$E'_{BI}(t) = E_{BI}(t) - E_{BI}(t-1)$$
$$RR'_j(t) = RR_j(t) - RR_j(t-1)$$

where the values for the derivative of the various quantities have been assumed to be equal to their delta across the interval to account for computational feasibility especially when taking into account the aim of the system to represent the process – as a first approximation – irrespective of the program duration. And given the provided definition of $Z(\,)$ and the described possibilities to assess its variations, what just said translates in what follows:

$$g(Z, Y'_C) = \left[Y'_C(t) + \left[\overline{Z(t)}\,Z(t-1) + Z(t)\,\overline{Z(t-1)}\right]\right]$$

Z(t)	Z(t-1)	$\overline{Z(t)}$	$\overline{Z(t-1)}$	$\overline{Z(t)}$ Z(t-1)	Z(t) $\overline{Z(t-1)}$	$\overline{Z(t)}$ Z(t-1) + Z(t) $\overline{Z(t-1)}$	Y'c(t)	g(Z, Y'c)
0	0	1	1	0	0	0	0	0
0	1	1	0	1	0	1	0	1
1	0	0	1	0	1	1	1	1
1	1	0	0	0	0	0	1	1

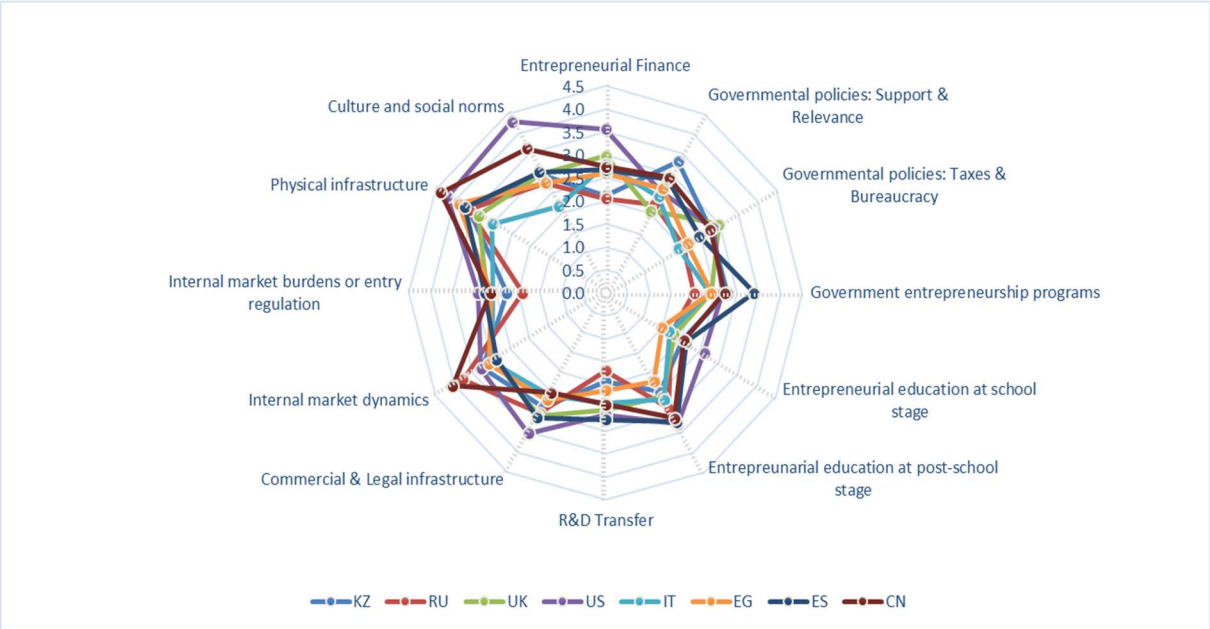
In the table provided, a **0** is assigned when the variable has not changed from its previous value, that is $Z(t)$ has not changed from $(t-1)$, $Z(t-1)$ from $Z(t-2)$, and $Y'_C(t)$ has not changed from $Y'_C(t-1)$. The value is assigned to **1** if they have changed. This approach allows to trigger the usage of the contingency measures previously defined.

One of the assumption made in the modelling phase given the complexity of the system is that it would be possible to represent the relation occurring between outputs and inputs with a linear function in the form $y = Ax - B$, at least in the short term, where the choice for the negative sign for B originated from the knowledge that the initial investment implies debts. This allows simpler computations (especially when translating this into its monetary value using EVM) but at the same time requires to fix the maximum Δt for which the induced error is acceptable and the information extracted by the modelling usable as a first order approximation of the actual BI performance expected value.

Additionally, it is necessary to take into account that the incubator hosts a cohort of residents at each cycle and therefore we have to deal not with $y(t+1) = Ax(t) - B$ but with a system of equations each covering a specific Resident's contribution to the overall output of the system and requiring to be handled consistently in the same way, that is $Y(t+1) = A(t)\,X(t) - B(t)$, which implies that we can linearize only for the maximum common Δt across all dimensions of the system. The selected approach takes advantage of the opportunities offered by the usage of EVM for project management and linearization on short time intervals for planning and forecasting. EVM allows to easily understand the progress and issues (if any) of each Resident's project as well as of the BI in its entirety. Linearization allows forecasting in the short period despite the complexity of the operation environment.

In the chosen approach the parameter A represents the proportionality existing between input and output (given more input at equal performance the output increases), while B represents the required initial investment that offsets negatively performance as it implies cover the initial

loan/investment before being able to have profit. Both ***A*** and ***B*** are influenced by the external context – and this is why in the formulation of ***Z*** have been considered the dependency from the ***PESTL*** context. The latter varies from location to location and in time, however, the speed of variation when considering the known trends of the Economic cycle, technology and socio-cultural evolution, is much longer than the standard weekly or monthly performance analysis interval. To this extent the abovementioned aspects of the external parameters have been considered constant and have been computed (for the studied countries) based on the extensive information available in the Global Entrepreneurship Monitoring (GEM) analysis of over 80 economies profiles for Entrepreneurial Framework Conditions, Entrepreneurial Behaviour and Attitudes along with several studies connecting National Culture and Entrepreneurship (GEM, 2016 / 2017 / 2018).



	Entrepreneurial Finance	Governmental policies: Support & Relevance	Governmental policies: Taxes & Bureaucracy	Government entrepreneurship programs	Entrepreneurial education at school stage	Entrepreneurial education at post-school stage	R&D Transfer	Commercial & Legal infrastructure	Internal market dynamics	Internal market burdens or entry regulation	Physical infrastructure	Culture and social norms
KZ	2.1	3.3	2.8	2.8	2.0	2.5	1.9	2.9	3.3	2.3	3.6	3.0
RU	2.1	2.2	2.1	2.0	1.7	2.9	1.7	3.0	3.8	1.9	3.6	2.8
UK	3.0	2.1	3.0	2.4	1.8	2.6	2.6	3.1	2.9	2.7	3.4	3.0
US	3.6	2.5	2.8	2.7	2.6	3.3	2.7	3.5	3.3	2.9	4.2	4.3
IT	2.8	2.4	1.9	2.4	1.7	2.7	2.4	2.6	3.0	2.6	3.0	2.2
EG	2.6	2.6	2.2	2.4	1.5	2.2	2.1	2.7	3.1	2.6	3.9	2.8
ES	2.7	2.9	2.5	3.4	2.1	3.3	2.8	3.1	2.9	2.8	3.7	3.0
CN	2.8	2.9	2.8	2.7	2.1	3.1	2.4	2.5	4.0	2.6	4.4	3.6

The main reason for this approach is to recognise that such aspects are crucial for the success and sustainability of businesses and, therefore, cannot be ignored in the modelling effort despite the difficulty this implies partially due to the complexity this adds and partially due to the patchiness/lack of information for some of the specific counties in which the field-research has been conducted.

Given the number of parameters and variables whose interplay is being considered, the adoption of radar diagrams – with the various quantity expressed in terms of percentage (%) – has been considered as the best presentation option as it offers the possibility to see all at once how different dimensions such as production, costs, human resources, marketing, etc. map out in time or across residents.

Based on the previous parameters and the literature, we have computed the parameters that will be used to represent the influence of the PESTL and socio-cultural aspects of the modelling as reported aside where α refers to those parameters that tend to influence most the operation and β those that tend to influence more the structure. Each has been computed as the average of the parameter set that has more influence on operation and business structure respectively.

	Alpha (α)	Beta (β)
KZ	2.6	2.8
RU	2.6	2.4
UK	2.7	2.7
US	3.4	3.0
IT	2.5	2.4
EG	2.6	2.5
ES	2.9	3.0
CN	3.2	2.7

In relation to the Technology evolution and in order to take it into account along with the other external influence on the overall modelling of the system, the technology trend has been factored in taking into account the law of Moore and Gartner's Hype Curve. The two have been considered in conjunction as the introduction of a new technology could prove disruptive for an established business and even more so for a start-up. Taking into account the average rate of evolution of technology (with an 18-24 months cycle of innovation) the aside formulation for Gartner's Hype Curve has been accounted for.

Being BI, Accelerators and Science-Parks environments fostering innovation, it seemed logical to consider the potential impact of technology evolution and launch on the process. To this extent Moore and Kurzweil laws were into account. The innovation cycle is assumed to span 18-24, this means that while in a short program (such as those of an accelerator) is plausible that the Resident idea falls in the rapid growth phase, for the longer programs there is a significant risk that a new emerging technology may cause significant (if not devastating) impacts on the Residents' possibility of success. Therefore, in the selection process it is essential to consider (among the other risks) that technology may evolve at speed and be subject to Gartner's Hype-cycle.

The variations in the economic cycle and the market need to be accounted too in the risk analysis while selecting future Residents, however, the overall fluctuation is much longer on average and therefore easier to control as, according to (Lucchese & Pianta, 2011), *"in upswings faster economic (and productivity) growth in industries is sustained by efforts to develop new products, while in downswings, due to a shortage of demand, process innovations aiming at restructuring result more relevant in supporting the increase in value added (or in containing its fall)"*.

In the proposed modelling is stressed that the external parameters are not directly affecting the Residents but are rather mediated by the intervention of the Incubator/Accelerator manager thanks to specific actions that could vary from training provision to procurement of specific equipment. Therefore while the response to a change in a tariff or regulation may translate in a training (immediate response to a change that may not need to be repeated as such in time and therefore is assimilated to an instantaneous variation δ in the model); the purchase of a 3D printer to cater for the increasing widespread use for prototyping is an action that will last in time and will be available to a number of consecutive classes representing a kind of legacy of a management decision taken (and therefore represented with an $\int$ in the model). The fact that each resident may have different needs could be amplified by the fact that the Incubator/Accelerator may be multi-sector/vertical rather than mono-sector/vertical. This in turn implies that not all changes occurring outside will affect in the same way all resident if at all. This is represented using the combination symbol in the model.

The variance in the design and implementation of incubation/acceleration programme is such that the period varies from a minimum of 3 months to a maximum of 60 month (for accelerators the span is form a minimum of 2 weeks to 24 weeks on average but with seeded programmes ranging from 2 to 4 months and second stage programmes lasting up to 6 months). This means that the various checks (feedback-loop) needs to be adjusted depending on the duration of the

programme. This implies that in the formulas Δt varies from one week to a quarter. Additionally, given the fact that the operations occurring within $f_C()$ and $f_{R_j}()$ require time to be executed the output function Y is presented as a discrete one where $Y(t+1)$ as a function of $X(t)$. The choice of the monitoring and assessment evaluation frequency is, therefore, very important given the reported variance in programme duration and the time required to create results – albeit incremental – in the Residents' project.

Figure 6 - The hype cycle and its stages' indicators (Steinert and Leifer, 2010)

It has already been pointed out that the output of the overall BI is given by

$$Y(t+1) = \sum_{j=1}^{m} Y_{R_j}$$

while the average output of a generic resident j is given by:

$$Y_{R_j}(t+1) = \alpha E_{R_j}(t)\, I_{R_j}(t) - \beta E_{R_j}(t) - RR_j(t) \qquad \forall j \in \overline{1,m}$$

Where E_{R_j} stands for the ***Resident's Expenses***, I_{R_j} for the ***Resident's Income***, α and β represent the external context influence previously explained, and RR_j that stands for ***Residents Remedial/Requests*** (already explained) and that represent the intervention planned to cover a performance problem or cater for a non-planned (yet approved need that will be included in the BI expenses in the following reporting period and as such needs to be accounted for in a budget revision).

When considering not the average expense per resident but the actual ones and taking into account that each resident has a set of expenses depending on the BI business model (for example, a fee for the usage of the space or certain facilities, etc.) as well as the fact that a

specific resident may receive an injection of external capital in exchange for equities, then the generic resident income (net of the free resources provided by the BI) translates in:

$$\boldsymbol{X_{C_j}(t) = SR_{R_j}(t) + EI_{R_j}(t)}$$

Where $\boldsymbol{SR_{R_j}}$ stands for ***Sales/Revenue*** and $\boldsymbol{EI_{R_j}}$ for ***External Investment*** respectively generated and received by the generic resident $\boldsymbol{j}$; given the fact that $\boldsymbol{SR_{R_j}(t) = VP_{R_j}(t)PT_{R_j}(t)}$ where $\boldsymbol{VP_{R_j}}$ stands for the ***Volume of production*** and $\boldsymbol{PT_{R_j}}$ for ***Product/Service Price Tag*** we have that:

$$\boldsymbol{VP_{R_j}(t) = \frac{X_{C_j}(t) - EI_{R_j}(t)}{PT_{R_j}(t)}}$$

Taking into account that based on the same approach used to define $\boldsymbol{f_C()}$ we have:

$$\boldsymbol{f()_{R_j} \Rightarrow Y_{R_j}(t+1) = A_{R_j}(t)\, X_{C_j}(t) - B_{R_j}(t)}$$

where

$$\boldsymbol{A_{R_j}(t) = \alpha E_{R_j}(t) VP_{R_j}(t) = \alpha \frac{E_{R_j}(t)\left[X_{C_j}(t) - EI_{R_j}(t)\right]}{PT_{R_j}(t)}}$$

$$\boldsymbol{B_{R_j}(t) = \beta \left\{ II_{R_j} + \left[\int_0^t \left(E_{R_j}(\tau) - DP_{R_j}(\tau) d\tau \right) \right] - X_{C_j}(t) \right\}}$$

In which $\boldsymbol{E_{Rj}}$ stands for the resident's ***Expenses***, $\boldsymbol{II_{Rj}}$ for the resident's ***Initial Investment***, $\boldsymbol{DP_{Rj}}$ for the resident's ***Debts Paid*** (that is the part of the ***Initial Investment*** that has been repaid to date and therefore needs to be detracted or would be accounted twice). Once making the necessary substitutions the model description of the generic resident $\boldsymbol{j}$ output is given by the following quadratic equation that has taken the place of the previous linear one:

$$\boldsymbol{Y_{R_j}(t+1) = \underbrace{\frac{\alpha E_{R_j}(t)}{PT_{R_j}(t)}}_{a} X_{C_j}{}^2(t) - \underbrace{\left(\frac{\alpha E_{R_j}(t) EI_{R_j}(t)}{PT_{R_j}(t)} + \beta \right)}_{b} X_{C_j}(t) - \underbrace{\beta \left[II_{R_j} + \int_0^t \left(E_{R_j}(\tau) - DP_{R_j}(\tau) \right) d\tau \right]}_{c}}$$

The adoption of the Earned Value Management approach to measure the progresses and alignment to plans of the various Residents' work (as these are considered as projects) has provided a consistent ad feasible way to assess the output of system and to exploit fairly simply tools to monitor the process and alert in case of issues in the Residents' progresses and project development. Furthermore, it made possible to describe the system functioning in terms of inputs and outputs (albeit translated into monetary form) and thus is now possible to also compute the system efficiency and effectiveness.

The efficiency $\boldsymbol{\eta}$ of a system is defined as the percent ratio between produced output and input required for producing that specific output:

$$\boldsymbol{\eta := \frac{Input}{Output}\%}$$

According to (Ackoff, 1999), effectiveness ($\boldsymbol{H}$) can be computed as the product of efficiency $\boldsymbol{\eta}$ for the value of the outcome $\boldsymbol{V}$, that is $\boldsymbol{H := \eta\, V}$, in case of several products the overall

Effectiveness can be defined as the composition – the simple sum – of the various individual effectiveness, that is:

$$\boldsymbol{H = \sum_{j=1}^{m} \eta_j V_j}$$

and, therefore, the overall effectiveness of the BI is computed as:

$$\boldsymbol{H_{BI} = \eta_{BI} V_{BI} + \sum_{j=1}^{m} \eta_j V_j}$$

The value of the outputs – of the BI control function as well as of the Residents' efforts should be computed as a function $\boldsymbol{f_1()}$ of the overall output of each of these processes as previously expressed or:

$$\boldsymbol{V_C := f_1(Y_C)}$$

$$\boldsymbol{V_{R_j} := f_1\left(Y_{R_j}\right) \quad \forall j \in \overline{1, m}}$$

Where, exploiting the meaning of EVM indexes it is possible to define $\boldsymbol{f_1()}$ as the probability to have both CPI and SPI greater or equal than 1, that is:

$$\boldsymbol{f_1() := P\left([CPI \geq 1] \wedge [SPI \geq 1]\right)}$$

The chosen approach allows not only to define and compute the system efficiency and effectiveness but also to compute/estimate the damage caused by any resident failure either during or after the period of residence. According to (Relan, 2012) around 90% of residents fail either during the programme or after it, this implies that there are two kind of damage the failure of a resident cause, one is a dame in terms of image (and applies mostly to those that fail after graduation) and the other is economic and relates to those that fail while still in the programme. Therefore, if the residents are not well selected and/or the BI program is not well designed – or implemented – there is a high risk that the overall BI damage loss for could be significant. The damage/loss/cost associated to the failure of a resident (company being incubated/accelerated) can be described as follows:

$$\boldsymbol{D_{BI} := \{DI_{BI} \wedge DE_{BI}\}}$$

Being $\boldsymbol{D_{BI}}$ the overall damage suffered by the BI, $\boldsymbol{DI_{BI}}$ the Image Damage and $\boldsymbol{DE_{BI}}$ the Economic Damage. The damage in terms of image is exacerbated in case of early failure of incubated companies and therefore it is possible to argue that:

$$\boldsymbol{DI_{BI} \propto K}$$

being $\boldsymbol{K}$ the number of residents that have failed after successfully completing the program and in a period of no more than 3-6 months.

$$\boldsymbol{K := \sum (FC_{3m} + FC_{6m})}$$

Where FC_{3m} and FC_{6m} represent respectively the companies failed after three and six months from graduating. Additionally, The Image damage is proportional to the number of residents failing after graduation and inversely proportional to the time elapsed from graduation and before failure, that is:

$$DI_{BI} \propto \left\{ \frac{1}{T_{f_{av}}} \wedge \sum_{i=1}^{K} F_i \right\}$$

Where F_i indicates the failure of a generic resident i and $T_{f_{av}}$ the average time to failure of failed residents. The image damage is particularly important as one of the dimensions of the BI effectiveness is measured by the number of successfully graduated companies that are still surviving after 5 years. Therefore, early indicators of effectiveness issues are the number of graduated companies not surviving 3 years, a year, 6 months and 3 months respectively with the latter (3-6 months) being an indicator of the presence of an unresolved ***"Kill factors"*** in the programme design or implementation as it has not been able either to assess the long term viability of the residents' idea or to equip the resident sufficiently for being able to survive the entry in the market.

The economic damage incurred by the BI in case of residents' failure can be computed as the sum of the economic losses per failed resident which are basically represented by the sum of what has been given to the resident in terms of resources (seed capital, equipment usage/wear & tear, space occupation, assistance time, training time, free services provision, administrative work, etc. X_{C_i}, E_{BI_i}, Z_{C_i}), the loss of income (LI_{BI_i}) that their failure gives – if they are still in the program – minus the fees they have already paid (I_{BI_i}).

$$DE_{BI} := \sum_{i=1}^{K} \left\{ \int_0^t \left[X_{C_i}(\tau) + Z_{C_i}(\tau) + E_{BI_i}(\tau) - I_{BI_i}(\tau) + LI_{BI_i}(\tau) \right] \right\} d\tau$$

Given the selected approach is possible also to compute the $IRPC_{BI}$ (Integrated Residents Program Cost) and the $iRPC_{BI}$ (Individual Resident Program Cost) which are respectively:

$$IRPC_{BI} := \int_0^t \left[X_{C-Cost}(\tau) + Z_{C-Cost}(\tau) + E_{BI}(\tau) - I_{BI}(\tau) \right] d\tau$$

$$iRPC_{BI} := \int_0^t \left[X_{C-Cost_j}(\tau) + Z_{C-Cost_j}(\tau) + E_{BI}(\tau) - I_{BI_j}(\tau) \right] d\tau \qquad \forall j \in \overline{1,m}$$

where X_{C-Cost} represents the overall cost incurred to provide for the Residents, Z_{C-Cost} the overall cost incurred for managing the external variables and shield – to the extent possible – the Residents, X_{C-Cost_j} the cost incurred to provide for the specific resident j, and Z_{C-Cost_j} the cost incurred for managing the external variables and shield – to the extent possible – the specific Resident j.

Conclusions

The conducted research has allowed to formulate a functional model of the incubation process and identified a set of metrics that can be used to monitor the efficient and effective functioning of the system (reported in a previous paper). The model allows formulating a coarse forecast of the output evolution as well as plan for adjustments in the inputs and management of external parameters. The model has been constructed taking into account the ten principles of Cabral, the best practices reported in literature and the outcomes of the interviews conducted with a dozen of institutions. However, this area is rapidly evolving with the appearance of the *"Virtual*

Business Incubators/Accelerators" as well as with the growing adoption of business incubation/acceleration in the low/middle-income counties (such as Kazakhstan, Belarus, and Egypt). This implies that there is a need for a constant update and monitoring of the domain to look for new developments/approaches that should be included in the model. This is a clear limitation, however, the model has been designed in such a way that it could easily accommodate changes in the practice without needing to be changed as a whole but only in some of the functions (and exploited variables) which can be therefore used as parameters.
At present, the research is in the experimental phase but this has not yet been completed and therefore the validation of the model is still pending which is a further limitation. The planned future work is to transform the present prototype into a minimum viable product of a decision support and information management system extension and develop a set of case studies based on its adoption by partner institutions such as STARTAC Business Incubator in Italy.

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Appendix 1 – Business Incubator Definitions

Definition	Analysis
A small business incubator is a facility that aids the early-stage growth of companies by providing rental space, share office services and business consulting assistance. (Allen and Rahman, 1985)	Flexibility is not stressed yet is crucial as each entrepreneur and business idea is different. Business development processes include training, coaching, mentoring and as such is more than consulting assistance. Supporting by giving space (often rented although at favorable rates) and office services does not cover all needs of start-ups, especially high-tech ones, and unless it is flexible, some resources and help will not allow to survive once completed the period of tenancy. This definition could have been suitable for the 1980s but is not adequate for now.
The universal purpose of a business incubator is to increase the chances of a firm surviving its formative years, but the business incubator also adds value by maximizing the firms' growth potential. (Allen and Rahman, 1985)	This is definition is universal in the sense that describes the *"purpose"* of a business incubator. At the same time when replacing *"surviving its formative years"* with *"overcoming its initial or fast growth/reshape phases"* makes it is also valid for Business Accelerators.
A small business incubator is a facility which promotes the early stage development of a for-profit enterprise. (Plosila and Allen, 1985)	This definition is limiting as it may be possible to incubate social enterprises as well as non-for-profit ones, additionally, it does not provide any indication of what is available (People, sources, resources, spaces, courses, Mentors, funds, etc.)
A multi-tenant facility which provides entrepreneurs with: (1) flexible leases on small amounts of inexpensive space; (2) a pool of shared support services to reduce overhead costs; (3) some form of professional and managerial assistance; and (4) access to or assistance in acquiring seed capital. (Brooks, 1986)	This definition provides a clear list of the essential resources and services required for residents company and in particular it points out the fact that while seed capital is important, flexible lase, inexpensive work-space and professional and managerial support are also important. At the same time, it does not mention training or other forms of personal/professional development.
Buildings in which a number of new or growing businesses can locate and operate at much lower costs than in conventional space where market rates prevail. Incubator facilities are characterized by access to shared, centralized facilities such as clerical and administrative help, receiving and shipping facilities, conference rooms, computers, and word processors, and other business assistance. (SBA, 1986) in (Udell, 1990)	This definition stresses the aspects of co-working space and access to low-cost centralized services which are suitable for newly started companies. As such it does not mention the provision of supportive training resources and funds. This definition could have been suitable for the 1980s but is not adequate for now
A business incubator is defined as a facility that provides affordable rent to new and small firms, shared office and logistical services, and arranges business management and financial assistance. (Allen, 1988)	This definition is more restrictive than most of the other definitions reported and also of those the same author has provided just a few years before. Here the *"creation of added-value"* is dropped and the focus is concentrated on infrastructure and services.
By controlling [four types of resources: secretarial support, administrative assistance, facilities support, and business expertise including management, marketing, accounting, and finance …] the business incubator seeks to effectively link talent, technology, capital, and know-how in order to leverage entrepreneurial talent and to accelerate the development of new companies. (Smilor and Gill Jr., 1986)	This definition focuses on the available resources on the one hand but at the same time stresses the fact that the BI should be able to links resources to the talents of the residents in order to enable a faster and more secure development of enterprises. In this respect this definition could also well adapt to accelerators and science-parks, provided to stress/differentiate the output (here labelled as new companies).

Definition	Analysis
Reducing the rate of failure in small business by assistance in the critical stage of business development—the early years. (Kuratko and LaFollette, 1987)	This definition focuses only on the overall objective underpinning the establishment of a business incubator but does not indicate what kind of assistance and support could/should/would be provided to resident companies.
A new business incubator is an innovative system designed to assist entrepreneurs, particularly technical entrepreneurs, in the development of new firms. (Smilor, 1987)	Also, in this case (like the previous one) the definition does not focus on the process or structure but rather on the aim, additionally, it seems to suggest that business incubation should be mostly focused on technical firms. Overall, it reflects the feeling of the times when it was coined.
An incubator [is a] building, section of a building, or adjacent buildings that provide a nurturing environment to . . . assist in the growth and development of new enterprises. (Campbell and Allen, 1987)	The definition focuses only on space (*"building or adjacent buildings"*) that can be used by residents for the development of new enterprises but does not mention what is a *"favorable environment"* the availability of support from people, courses, sources, services, tutors, access to funds, which should certainly be offered by a business incubator are not discussed, however, this was probably the understanding at those times. Just like Smilor the definition reflects the approach of the time it was made.
The business incubator is a new concept in entrepreneurship and economic development which utilizes large, often old, building to house new small businesses. The unique aspect of incubators is that the businesses share administrative services in addition to renting space in the building. Typically, the incubator provides clerical and receptionist staff, computer and copying equipment, accounting/bookkeeping help, and conference rooms. Management assistance is generally provided by either the incubator staff or outside consultants, and financing is often available. (Fry, 1987)	Despite covering a few relevant aspects of service and support provision, this definition is still mostly focused on the availability of cheap working space, shared services, training and personal/professional development aspects are not addressed. This confirms the fact that the approach has greatly evolved in time from the initial one set in 1959 when Joseph L. Mancuso opening the Batavia Industrial Center in a warehouse to save property taxation.
They [business incubators] provide secure, affordable, flexible, well equipped space in which the entrepreneur can work (often day and night). They [business incubators] provide readily accessible support services (receptionist, clerical, data processing, copying, legal, accounting, machine shop, conference, fast food and other capabilities). They [business incubators] provide professional business management and technical consulting, together with access to seed and working capital, state and federal grants, loan financing, venture capital and R&D Limited Partnership (RDLP) funding, public and private stock offerings, and state equity financing. They [business incubators] often are associated with a university that can provide additional access to highly specialized analytical, computing and test facilities in an array of disciplines. They [business incubators] create an interactive community of entrepreneurs; academic and business interests that stimulate and encourage the sometimes fragile business incubation process. They [business incubators] often operate as a communications bridge with the community, and established enterprises that seek a window on emerging technologies and may provide growth capital for equity participation. (Merrifield, 1987)	This definition covers all aspects of providing start-up entrepreneurs with space for work, easily accessible support services, as well as professional and technical advice, access to capital and financing. In addition, the definition gives a picture of a business incubator within the university with the possibility of using special equipment, laboratories and resources in general. The vision of the business incubator as *"a link with the community and create enterprises that are looking for a window for new technologies and can provide capital growth for participation in equity"* is clearly presented.
Business incubation is an organized effort to bring together new and emerging businesses in a controlled environment. …. The main objective of a business incubator is to facilitate development of conditions and support systems that will ensure successful business operations. (Lumpkin and Ireland, 1988)	In principle, this definition clearly explains the concept (in terms of purpose) of a business incubator as an organization undertaking efforts to support and merge new enterprises with the provision of favorable conditions and the support system needed for a successful outcome. However, this definition does not shed light on the development of the would-be entrepreneur, his/her need for training and development which are crucial for *"successful business operation"*.

Definition	Analysis
By providing a variety of services and support to start-up and emerging companies, the incubator seeks to effectively link talent, technology, capital, and know-how to leverage entrepreneurial talent, accelerate the development of new companies, and thus speed up the commercialization of technology. (Hisrich, 1988)	Here the concept of a business incubator is clearly expanded, what is more is that the emphasis is in the *"linking"* of very valuable aspects of a successful business as a way to *"leverage entrepreneurial talent, accelerate the development of new companies, and thus speed up the commercialization of technology"*. At the same time, the limit of this definition is that it focuses substantially on technology only as a business remit.
Business incubators are 'change agents' in the transformation of our economy from one that is based on large manufacturers to one with many new, small 'information age' firms. Business incubators address many of the failures of the marketplace—information costs, restricted capital flows, lack of services, business assistance and financing to new and small businesses. (Campbell, 1989)	In this definition the focus is on what a business incubator supposedly helps solving (although not all research on this aspect is in agreement). Indeed, the listed issues hamper the possibilities of would-be-entrepreneurs to turn their ideas into reality, however, the definition leaves open to interpretation how this can be achieved and - as such - does not provide sufficient guidance.
What is new and distinct about incubators is that these features of entrepreneurship [multi-tenancy, shared office services, business counseling] occur at one location. (Allen and McCluskey, 1990)	In this case the author stresses the fact that in one place there are [multi-tenancy, general office services, business consulting], but there is no attention to what all this is for and why the business incubator provides this. In this respect this definition does not differ much from the early ones and seems to ignore the personal/professional development aspects and the resident journey towards entrepreneurship.
Business incubators [have] a strategy whose focus is understood in relation to science parks and innovation centers and [have] a function of emphasis on business development and research development. A business incubator's strategic focus is on business development with low involvement in research development. A science park's strategic focus is on research development with little concern for business development. An innovation center's strategic focus represents a happy medium of business and research development. (Swierczek, 1992)	Here we have a combination of definitions where business incubator, science park, and innovation centers are covered. The author operates a distinction among the three based on their goals and functions. The interesting aspect of this approach is that it allows and encourages the design of a new entity the *"innovation center"* as a hybrid between business incubation and science park, this in turn opens the possibility to have business incubations aspects within a science park and therefore the two can coexist (which opens the possibility to design rather interesting business models for universities and companies the like).
Business incubators [are] mechanisms for community's to collaborate and to promote the development of technology-based firms. (Mian, 1994)	If we approach the understanding of business incubators from the point of view of community cooperation, then this is undoubtedly present in the issue under consideration, in the form of mentoring and financial support for entrepreneurs. But at the same time, there is no concept of a business incubator as an organization with certain functions (supporting start-up entrepreneurs - courses, resources, providing a place to work) and goals (such as supporting the launch of companies and business)
A business incubator [is] a locally based institution created to encourage and support new business development. (Markley and McNamara, 1995)	This definition is very vague as it could be applied also to an investment fund or any other initiative encouraging and supporting the development of a new business. Overall, it provides no information on how this will be carried out (courses, mentoring support and financing, etc.)
The university technology business incubator (UTBI) is a modern enterprise development tool employed by some entrepreneurial universities to provide support for nurturing new technology-based firms. (Mian, 1996)	This definition is rather narrow, it points out that university technological business incubators are *"modern tool for developing entrepreneurship"*, but it is not clear how support is given and what services are provided for *"developing new technology companies"*. Additionally, it is limited to technology-based developments only.
The purpose of a business incubator is to provide some combination of necessary resources in order to nurture a new and/or growing business to some level of maturity. (Greene and Butler, 1996)	This definition is focusing on the purpose of the business incubator, which is clearly indicated, but the functions that it assumes as an organization providing a range of services and services to new growing companies are not described.

Definition	Analysis
One popular vehicle to encourage new businesses in local economies is the business incubation program . . . [one of] a number of federal, state, and local government-sponsored intervention programs . . . introduced to facilitate the creation and growth of small start-up businesses. (Sherman, 1999; Sherman and Chappell, 1998)	In this case the authors provide a motivation underpinning the phenomenon in the USA in the 1990s rather than a proper definition. They explain why business incubation was created under government programs, however, there is no indication of what a business incubator is, its role, purpose and functions.
A business incubator may be defined as an organization which offers a range of business developments services and access to small space on flexible terms, to meet the needs of new firms. The package of services offered by a business incubator is designed to enhance the success and growth rates of new enterprises thus maximizing their impact on economic development. (Dulf. 1999)	A fairly broad definition, covering all aspects of the role and functions of a business incubator. An important aspect of this definition is that even though it does not mention explicitly training or professional development activities, still it refers to a *"package of services … designed to enhance the success and growth rates of new enterprises"*.
Business incubators provide one mechanism by which start-up businesses with high growth potential can be helped to succeed. (Roper, 1999)	This definition focuses on the observed impacts of the incubation process for potentially profitable ideas which are supported to develop into businesses (mostly in the USA), However, it is not made clear how this mechanism works.
Business incubators. . . nurture and grow start-ups in the Internet economy. They offer fledgling companies . . . office space, funding, and basic services such as recruiting, accounting, and legal - usually in exchange for equity stakes. (Hansen et al., 2000)	In this definition is clearly pointed out the resource-connected aspect of business incubation, however the services provision is limited to clerical and financial aspects while mentoring support and training provision are not considered. Additionally, the focus is limited to the Internet economy which is consistent with the approach and attitude on the period and that has dramatically changed after the burst of the so called *"dotcom"* bubble.
A controlled environment that fosters the care, growth, and protection of a new venture at an early stage before it is ready for traditional means of self-sustaining operation. In today's world, where information technology and the Internet are normal parts of the business environment, the term *"controlled environment"* could be either physical (real estate and office facilities) or virtual (networks). (Chinsomboon , 2000)	The Author derives this definition from an interesting comparison of a business incubator with a real incubator for the care and cultivation of *"micro-organisms or for the care and protection of premature or sick children"*. This comparison provides a fairly clear understanding of why the organization supporting and assisting a novice entrepreneur is called a business incubator. However, there is no description of the process applied to support companies in the framework of business incubation (resources, courses, financing, mentor support, training, etc.)
A business incubator is an economic development tool designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services. A business incubator's main goal is to produce successful firms that will leave the program financially viable and freestanding. (NBIA Website)	A fairly complete definition of a business incubator that comprises also a description of its purpose, at the same time, this definition contributes to blur the boundary between incubator and accelerator. Additionally, it does not specify that the target companies must be start-ups or high-tech thus suggesting there is the opportunity to have also non-tech settings. Overall, this is rather understandable given the fact that this is the definition provided by the National Business Incubation Association.
[An] eBusiness incubator is a service organization (individual or virtual) that provides a full-services range to design, deploy, and potentially operate an eBusiness, offering post-incubation…. Some of the services offered include advisory, funding, design, construction, and operations. The ultimate goal is to build an entity that can take an idea and rapidly (within weeks) develop it into a deployed initiative. (Lepeak, 2000)	A very interesting definition of a *"virtual"* business incubator, a fairly new phenomenon that started emerging during the *"dotcom"* bubble. Also, in this case the boundary between accelerator and incubator is blurred although presently a number of Accelerators offer a 2-3 weeks crash program while most Incubator programs last from a few months to several years.

Definition	Analysis
… a controlled environment -physical or virtual – that cares, and helps new ventures at an early stage until they are able to sell-sustain through traditional means… (Gonzalez & Lucea, 2001)	A fairly complete definition of a business incubator. Again, the emphasis is on an environment which is conducive to development and innovation and the support required until the venture becomes sell-sustaining.
The term incubator is used to describe high-tech business clusters, the role of which is to pool resources to provide *"brick and mortar"* facilities, hands-on help, personal connections and expertise These clusters sometimes provide the seed funding needed for early stage start-ups. (Roussel, 2001)	A fairly restrictive definition of a business incubator focusing only on high-tech firms even though it covers all relevant aspects of what a business incubator can presently offer to its residents.
the term 'business incubator' is in its generic sense often used to describe a wide range of organizations that in one way or another help entrepreneurs develop their ideas from inception through to commercialization and the launching of a new enterprise. … A business incubator is an organization that accelerates and systematizes the process of creating successful enterprises by providing them with a comprehensive and integrated range of support, including: Incubator space, business support services, and clustering and networking opportunities. (European Commission, 2002)	The European Commission definition is sufficiently general to cover most aspects of business incubation (including training and professional development although not explicitly mentioned) yet points out also the fact that there are several definitions and interpretation of the phenomenon.
A business incubator—in collaboration with the community in which it operates—is a producer of business assistance programs. (Rice, 2002)	The proposed definition considers the business incubator as a *"producer of business assistance programs"* in *"collaboration with the community"*, which assumes that it is part of a local ecosystem, however, this is not always the case. Additionally, this definition does not detail if it provides resources, courses, financing and services for residents.
A business incubator is a shared office space facility… that seeks to provide… a strategic, value adding intervention system of monitoring and business assistance… with the objective of facilitating the successful new venturing development while simultaneously containing the cost of their potential failure… It is important to keep in mind the totality of the incubator… It is a network of individuals and organizations. (Hackett and Dilts, 2004a / b)	This definition considers a business incubator as a single strategic system for the successful development of new enterprises, it stresses the strategic and value-adding purpose and limits the focus to *"venturing developments"*, additionally, it does not hint to what services, resources and facilities are provided. Nevertheless, this definition is at the base of the only model that provides also a clear definition of the effectiveness of business incubation and that has – to a large extent – inspired the present research (especially in terms of identifying an approach that could be used to model the process from a decision making and operation point of view).
Incubation should be considered as an interactive and dynamic new firm creation process with the purpose of stimulating people to start their own business and supporting start up enterprises in the development of innovative products. A real incubator it is not an office space with a desk. It should offer management services, financial assistance, juridical support, operational know-how and access to new markets, which can be done both in a physical or virtual space. ((Aernoudt, 2004) cited in Ryzhonkov, 2014)	A very interesting explanation of the very concept of business incubation. Aernoudt focuses on the purpose of the incubation process to explain what would be needed in order to achieve it ultimate purpose. This approach to the definition is very useful as it leads to think in terms of facilitation process, however, it does not address the issue of ideas selection which is crucial as resources available are limited and therefore not all ideas can be supported (especially when the incubator is privately owned).
Business incubation can be described as an innovative, evolving organizational form to create value by combining the entrepreneurial drive of a start-up with resources generally available to large or medium-sized firms. Business incubators nurture young firms during their formative years when they are most vulnerable, helping them to survive and grow into viable commercial enterprises. ((Hamdani, 2006) cited in Ryzhonkov, 2014)	The main value of this definition is in its reckoning that business incubation is an *"evolving organizational form"* as this captures one of the main issues in the analysis and understanding of this phenomenon. The process is evolving and adapting to local as well as global socio-economic context and therefore requires a different approach to both its definition and modelling, something that accounts for its constant evolution.

Definition	Analysis
Business incubation is a business support process that accelerates the successful development of start-up and fledgling companies by providing entrepreneurs with an array of targeted resources and services. These services are usually developed or orchestrated by incubator management and offered both in the business incubator and through its network of contacts. (NBIA[9], 2007)	A fairly complete definition of a business incubator which - once again - blurs the boundary between business incubation and acceleration. It is not restrictive in terms of residents as it simply mention *"entrepreneurs"* and does not specify the range of services offered while it points out that these could be *"developed or orchestrated by incubator management and offered both in the business incubator and through its network of contacts".*
Business Incubation is a unique and highly flexible combination of business development processes, infrastructure and people, designed to nurture and grow new and small businesses by supporting them through the early stages of development and change. (UKBI[10], 2007)	This definition (also originally available on the Diogene Business Incubator website) combines generality and flexibility, it does not restrict to a specific context (although refers explicitly to *"small businesses"*). All in all, this is the most general definition encountered and thus adopted in this research. The issue of focusing explicitly on *"small businesses"* is not seen as a limitation as all business have been small in their initial phases.
A business incubator is an economic development tool designed to accelerate the growth and success of entrepreneurial companies through an array of business support resources and services. (NBIA Website)	It is interesting to note that this definition of incubation relates to *"acceleration"*; this means that in the INBIA approach the distinction between Business Incubator and Accelerator is progressively vanishing. Additionally, the focus is only on economy thus ignoring social entrepreneurship which is on the other hand growing and leading in sectors such as the circular economy, the sharing economy and other aspects of innovation.

[9] National Business Incubation Association
[10] United Kingdom Business Incubation

Appendix 2 – Business Incubation Process steps description (from design to operation)

Step	Name	Description
s.0	Conception	In this stage the idea of opening a business incubator / accelerator / science park is conceived based on socio-economic context, funding availability and other consideration that depend on the owner of the initiative (state, private).
s.1 (**)	Design	In this phase a market analysis will be carried out along with a SWOT, PESTELE, and Porter's 5-Forces analysis. Opportunities at local and global level will be examined and intervention sector(s) decided. This phase is crucial to the success of the initiative as it will shape it and determine the offering to potential residents (by selecting the business model, format, etc.). If the design is not right the initiative will struggle to take off and may even fail. This is why this phase is highlighted as a critical step or challenge.
s.2	Approval	The concept developed in the previous stage (like any other business concept) will be assessed in terms of feasibility, viability, benefits, cost, expected impact and even ROI (if appropriate). If deemed viable the process will continue, otherwise it is discarded.
s.3a (*) (**)	Location selection	The selection of an adequate location is paramount as it needs to be viable, accessible, have enough space to accommodate the required facilities and the planned number of initial residents. It should be able to easily accommodate expansion and/or restructuring without the need to relocate. It should be close to the reference university (if present) or located in an industrial area that could then accommodate the graduated businesses.
s.3b (**)	Program (re-)design	One of the main characteristics of a business incubator / accelerator is the presence of a program designed for the residents (this is the only main difference with a science park that usually lacks this aspect). The program is a key and crucial part in the success of the residents as well as major attraction factor for the applicants as it defines the set of skills, knowledge and training support provided along with the duration of stay and graduation condition. The more the program is tailored to the residents, the more is the success probability. The program needs to be periodically re-evaluated (at least after every cohort graduation) to ensure continued relevance and include any lessons learned in the process.
s.3c (**)	Key personnel (re-) selection	The success of a business incubator largely depends on the quality, knowledge and experience of its staff, management and mentors (these are not the only success factor as the program, location, and connection… also play a crucial part). Choosing the right staff is therefore essential to ensure the success of the initiative. It has been mentioned that the program will be evaluated at least at every graduation, this also implies that staff will be periodically evaluated in terms of effectives and efficiency in their duties and performances. In case of unsatisfactory performances, it may be necessary to revise the staff composition.
s.3d (**)	(Initial) Resources acquisition	Resources are essential in the functioning of a business incubator/ science park. They range from infrastructure (network, computer, offices, and furniture) to services (accounting, communication, marketing, training, stationery, etc.) Some of the resources will need only periodic update/revision, other may need constant replenishment. Funding is potentially also part of the available resources and this often is a differential across the spectrum of initiatives. Although not necessarily, Mentors and Connection with Industries, Venture Capitalist, Business Angels etc. could be considered as resources as they are not staff.
s.4	Readiness	Once the steps s.3x are completed (or at least 3a and b and c and d close to completion) it will be possible to consider the preparation phase complete and move to the actual launch of the initiative. If major issues arise in respect of location, resources or staff, or if the operation context (socio-economic context local or global) changes to a point that the assumptions taken in the conception stage do not hold any more it may be necessary to return to the design phase and revise things.
s.5a (**)	Program promotion	The initiative may be extremely good, but it is not promoted and known would not attract applicants and therefore it will be necessary to have specific marketing and promotion activities carried out. The promotion will comprise social media as well as more traditional promotion channels such TV/Radio/Newspapers/Magazines/ Professional Associations/ Chamber of Commerce etc. The choice of promotional channel mix as well as the message will determine the kind of applicants applying and will therefore be an integral part of the success factors. However, this is less critical than the selection of the candidates as will be explained later on.
s.5b	Launch	The launch of the initiative will mark the start of operation of the system and its components, it requires the availability of the core infrastructure and personnel and possibly all resources. In some of the cases analysed, part of the resources, staff and infrastructure were completed after the launch – during the initial period of operation – and progressively adapted, revised and enriched throughout the life of the initiative (as part of its adjustments in time).
s.6	Call for candidates	This step is crucial to the recruitment of residents; it will have been designed alongside the promotion strategy in the initiative promotion stage. It will remain open until the cohort is completed and will reopen once the cohort is graduated. Unless there are change in the program or in the promotion, this activity will remain unchanged as it is mainly an administrative one.
s.7 (**)	Candidate selection	The selection of the candidates is paramount to assure an effective implementation of the initiative. Selecting the wrong candidates will lead possibly to their drop-out or failure and in the end will cost and damage the initiative. Selecting the right candidate means selecting candidates that have a good business idea (it may be challenging, innovative, disruptive) that is viable, attractive and sustainable. It also means that the candidate should have the right personal characteristics (entrepreneurship, determination, commitment, etc.) and it also means that the candidate business idea is somehow aligned to the initiative (in case of a vertical one or sharing common characteristics such as *"green"* or *"high-tech"* for the horizontal ones). It is worth

Step	Name	Description
		mentioning that a candidate with a great idea and an excellent business model idea may not be suitable for a specific program and this could be neither a shortcoming of the candidate or of the program, it may simply be a mismatch between the candidate expectations and those of the program being applied to.
s.8	Recruitment	This is another administrative process that will recur in the system. For every cohort, the selected candidates will be recruited and become residents in the infrastructure benefitting from its resources and services and forming a network of contacts (with mentors, potential investors and fellow-residents) that may help them in the future and especially once left the program after graduation.
s.9	Saturation	This is another administrative step. Every initiative such as a business incubator or accelerator usually works per cohorts of a specific size which is determined by the length of the program, the number of mentors, tutors, staff, available infrastructure, resources and lessons learned. Once the quota is reached, the cohort is closed, and the program starts. There may be cases in which the cohort is slightly smaller or larger, but this is not the norm and may be an indication of something that needs to be investigated. There may be a change in socio-economic context leading to less candidates or the program may be successful and attract more candidates that it is possible to retain. In either case it will be necessary to undertake a program evaluation.
s.10	Recruitment issues	If there are issues in the recruitment phase it could be for several reasons, staring with the promotion up to the design, thus the recruitment process will be monitored and if there are no specific issue it will continue until saturation (or near saturation of the cohort is reached. If on the other hand there are issues it may be necessary to revise the call for applicants, or the offerings, location, program depending on which stage the system is (first launch, subsequent cycles, etc.) and the circumstances and external factors. To account for this the model simply feeds back to the design (s.1) to allow reassess/modify or adapt all aspects.
s.11 (**)	Program execution & Resident monitoring	This is the core of the initiative (and also the part that requires the most the support of an IMS. It implies the access to the resources and services, the training and mentoring, the connection with the investors (venture capitalists, business angels, etc.) and the other residents as well as the alumni. The activities (including the training/education provided) are usually differentiated across residents in relation to the specific needs of each. The initiative may have an offering that is much larger than the needs of a specific resident (this is because it has to cover all the possible needs of present and potential residents), however, it may be possible that some very specific needs are not covered via the offerings of the initiative and in this case either they go unattended or they become additional (usually paid) services accessed/acquired on demand via the connections/mentors available in the context of the business incubator/science park.
s.12 (**)	Resident assessment	This is a procedural aspect that represents the final stage of the continuous monitoring of Resident performances and developments conducted during the program execution. It is somehow necessary as a final stage of the program to certify the program completion and Residents' achievements. This step has also another function that is connected to the initiative self-evaluation. The metrics collected in relation to residents will be updated and analysed to determine the efficiency and effectiveness of the initiative and help in fine-tuning, adjusting or even triggering a revision.
s.13	Program completion	The completion of the program is substantially determined by the results achieved by the resident in the cohort. It is marked by a combination of factors that depend on the model of the initiative, the stage of maturity reached by the residents and the opportunities available to them. It is worth pointing out that not all residents will complete the program, some will leave before completion (abandon) and others may fail during the program or immediately after. This latter case would be a sign that something is not working and trigger a program revision or at least some corrections.
s.14a	Graduation	This is a purely administrative and ceremonial step in the process, however, it marks the end of the program and the start of a new stage for the resident that will now be a company able to stand on its feet out in the market possibly with funding (via equities or other form) acquired and not only a business concept but prototypes and proof of concepts (if not even products) that would enable raising other funds or start trading.
s.14b	Retain	It may happen that for several reasons, changes in the market or technology, etc. the resident is not ready to graduate but retains value and potential. In this case it may be simply necessary to extend the period of residence and either join the next cohort or simply slightly delay the graduation. This may depend on the approach and policy of the business incubator/accelerator and if certainly not a frequent case, however it has been taken into account.
s.15	Program issues	In case the resident assessment has shown there are issues that are causing drop-out or failure or the need for retrain, it is possible that the program has shortcomings that were not identified previously and needs to be taken into account, in this case it will be necessary to trigger a specific program evaluation, otherwise it could simply be a problem connected to external factors or the residents personal circumstances and the program can continue as is (although a lesson has been learned and will be taken into account at the next periodic revision)
s.16 (**)	Program evaluation	This step is crucial to the sustainability and continued success of the initiative. It will be triggered periodically (potentially after every cohort graduation) or when there are serious issues in the program execution or the resident evaluation that suggest there is need to revise the operation modality or even the entire initiative model (including but not limited to business model, program, resources, etc.). It is a managerial activity that focuses on the effectiveness of the initiative as well as its efficiency. It requires the analysis of the collected metrics in a retrospective and historical fashion and a carefully analysis of gaps or deviations from the original expectations along with a revision of the assumptions and results. It can lead to simple adjustments or an entire re-design of the program and initiative reference model as well as – potentially – to its termination.

Step	Name	Description
s.17	Corrections	The analysis of the program may identify the need for corrections or even redesign. To this extent it is important to analyse the effectiveness and efficiency of system performances along with the achievements of the residents and the performances of the alumni. The information thus gathered will be used to decide what action to take, if it is enough to apply adjustments to the program, facilities or trainings or to go for a more significant (or even radical) redesign.
s.18a	Adjustments	Depending on the outcomes of the program evaluation, the required adjustments are performed. This could entail reorganize the available space, the services, the order of the training or the monitoring activities. It may require to stage the program in a different way (for example simply changing the timing of certain events like the investor visits or similar) or the frequency of mentoring sessions, or allow a more *"personalized"* fruition of the program based on residents needs analysis. It could even simply mean to acquire some extra resources or services.
s.18b	Redesign	This step is crucial to the long-term sustainability of the initiative as it may be necessary in time to adapt and change depending on external/internal factors. If redesign is required, then the process will have to re-start and this would usually happen after the graduation of the current / last cohort engaged in the program. Especially if there are multiple cohorts it will be necessary to initiate the revision after the last has completed or before it starts to avoid creating a *"no man's land"* situation during the transition. The results of the processes that follow may even bring to the closure of the initiative if the analysis of its performances and viability were to give a negative outcome. For example, the Business incubator of NARXOZ University MOST transitioned into an accelerator after the success of 5 of its residents and the subsequent change in the nature of the applicants.

Appendix 3 – From Idea to Market process steps

Step	Name	Description
s.0	Idea	In this stage the would-be entrepreneur develops and refines the idea of the business that s/he wants to start. This passage is crucial for the development of a viable concept (and at times proof of concept) that will be used to pitch for funding enabling the development of the idea into a product or service.
s.1	Application	Once the idea is worked out, an effective presentation and a business plan need to be prepared to apply for funding or access to a business incubator/accelerator/science park. The level of detail and quality of the business plan is what often makes the difference from being reject or accepted along with the *"perceived"* potential economic profitability of the idea (its viability is often – if not in almost all cases – not considered sufficient for funding/selection).
s.2	Approval	If the proposal is approved (based on its novelty, appeal and economic potential) the required initial funds (and resources) are made available and agreements are set in place to rule the duties and entitlements of the various parties. This stage is the equivalent of the Project Charter approval for a project.
s.3	End	If the proposal is not approval either new opportunities are sought, or the entire idea is abandoned.
s.4	Access to resources	After approval and acquisition of the basic resources, the latter are made available and accessible to the would-be entrepreneur. The new entity is usually registered and, thus a new company formed, contracts are issued and signed, and the overall process can start. This stage is equivalent to the formal kick-off of a project.
s.5	Initial training	If required, at this stage, the would-be entrepreneur would access some initial training (this happens mostly in BI or when the subject has a clear understanding of own limits and weaknesses). This is a critical stage in the process as if there are significant gaps in the know-how or skills of the would-be entrepreneur (or team), the probability of failure increases substantially.
s.6a	Further training	If required, at this stage, the would-be entrepreneur would access some further training (this happens mostly in BI or when the subject has a clear understanding of own limits and weaknesses). This stage is similar to the previous, however, while in a BI it will be triggered by a Resident's assessment, outside a BI it will be entirely up to the would-be entrepreneur to identify the need and gap and take action, failure to do so will increase substantially failure risks.
s.6b	Use of resources	The available resources are at this point engaged in the transformation of the idea into the final product/service as conceived (or its evolution). Also, in using the resources there will be a progression as the design phases will move from early staged to pre-prototyping, creating mock-ups and poofs of concepts that will progressively evolve into the prototype.
s.6c	Use of services	Several internal/external services will be accessed such as payroll, tax/legal advice, etc. as per the needs and maturity evolution of the new company. In a BI most of these services will be provided at a convenient price (if not even for free) depending on the adopted business model and available resources. In any case, the BI will possibly offer a better-quality service for the same amount than the outside market.
s.7	Prototyping	In this stage the idea starts to be turned into a product/service using the resources available. The process is likely to undergo several refinement cycles passing from mock-ups to early prototypes up to when the first minimum viable product.
s.8	Issues	Every stage of the product/service evolution is/should-be checked for improvement and defects elimination via reiteration and testing (possibly with the intended end-user). If problems are found the process is repeated, otherwise progresses to the next stage.
s.9	Pre-production	The tested prototype will reach a stage where small production batch can be made and delivered for distribution (mostly to early users). This will help establishing if the product/service is ready for launch (or how close it is). Early adopters and supporters will test and use the product/service providing invaluable feedback.
s.10	Issues	If during testing and/or validation with the user of the □-/□- product exhibits issues, requires improvements or the like, it will be necessary to undertake further developments or design revision.
s.11	Launch	In this phase the product/service of the new business is promoted to the market using the experience gained with the early adopters and exploiting their support (in terms of *"word-of-mouth"* etc.). Marketing and communication will play an essential role in this stage and are often supported by the BI not only in operative terms but also in terms of image and reputation.
s.12	Operation	At this stage the new business has entered the market and *"business-as-usual"* has started and the incubation/acceleration phase has come to an end. From this point onward the new business development will basically depend entirely on the entrepreneur's skills, abilities, know-how and decisions, therefore, this marks the transition from the protected and supportive environment of the BI into the competitive (and potentially hostile) market.
s.13a	Production	This is the core of the *"business-as-usual"* process where the product/service will be routinely produced/delivered. It is the phase consuming the majority of the resources and providing the assets that will generate company revenues. It requires constant monitoring and improvement to maximise results while minimising waste.
s.13b	Promotion	This is the work-phase that supports production in the effort to create revenues and added value. It requires understanding of the local market, socio-economic and cultural context. Here is where the business will have to exploit information and knowledge gathering to support the business effort. The analysis of business strengths, weaknesses, threats and opportunities

Step	Name	Description
		(SWOT) as well of the overall context (PESTLE) play here a crucial role. If the entrepreneur has well understood how to make good use of the information collected internally (via own Information Management System) and externally (from media, customers, retailers, distributors, suppliers and even competitors) the probability of success are increased.
s.14a	Sale	This phase is where the efforts of promotion and production are transformed into revenues and profit that will ensure company sustainability and growth. It requires monitoring and will – potentially – provide hints to adjustments to be applied to the design/production as well as marketing and promotion. Data gathered in this stage (along with those from production) are used to inform the business strategy alongside the info gathered from other sources.
s.14b	Maintenance	This phase is crucial to the sustainability of the business. Every product/service may incur in production/delivery issues that – unless addressed and solved – will compromise the image of the product/service and, therefore, of the business potentially causing serious issues when not even overall failure. Maintenance is also a way to strengthen the relation with the customers and – potentially – generate new ideas for products or services.
s.15	R&D	The sustainability of a business depends on its ability to satisfy the needs of the market, this means that as the market evolves, so has to do the business offerings. R&D is the phase where ideas and suggestions coming from the various division of the business, the supply chain and the customers (even the competitors) can be analysed, combined and used to generate new products, services and solutions thus ensuring constant fit for purpose to the business. Failing to do so risks creating a situation where business products/services become obsolete/less desired and progressively lose traction-on and share-of the market ultimately undermining the long-term viability of the business itself.
s.16	End	This phase is reported for the sake of completeness, however, once a company has accessed the market, its end of operation is the least desired and less expected step, which may occur but is not recommended.